CHAPTER

1

Some Basic Concepts, Mole Concept and Stoichiometry

DPP 1.1

Significant Figures, Rounding Off and Dimensional Analysis

Subjective Type

1. Express each of the following in SI units.
   (i) 93 million miles (this is the distance between the earth and the sun).
   (ii) 5 feet 2 inches (this is the average height of an Indian female).
   (iii) 100 miles per hour (this is the typical speed of Rajdhani Express).
   (iv) 0.74 Å (this is the bond length of hydrogen molecule)
   (v) 46°C (this is the peak summer temperature in Delhi).
   (vi) 150 pounds (this is the average weight of an Indian male).
2. Express the results of the following calculation to the appropriate number of significant figures:
   (i) $\dfrac{3.24 \times 0.08666}{5.006}$ (ii) $\dfrac{(1.36 \times 10^{-4})\,(0.5)}{2.6}$
   (iii) $0.582 + 324.65$ (iv) $2.64 \times 10^3 + 3.27 \times 10^2$
   (v) $943 \times 0.00345 + 101$
3. The mass of a piece of paper is 0.02 g and the mass of a solid substance and the piece of paper is 20.036 g. If the volume of solid is 2.16 cm^3. Calculate the density of the substance up to proper number of significant digits.

Single Correct Answer Type

4. One micro gram is equal to:
   (a) 10^{-3} g (b) 10^3 g (c) 10^6 g (d) 10^{-6} g
5. Significant figures in 0.00051 are:
   (a) 5 (b) 3 (c) 2 (d) 4
6. The number of significant figures in 6.02×10^{23} is:
   (a) 23 (b) 3 (c) 4 (d) 26
7. Express 0.006006 into scientific notation in three significant digits:
   (a) 6.01×10^{-3} (b) 6.006×10^{-3}
   (c) 6.00×10^{-3} (d) 6.0×10^{-3}
8. The proper value of significant figures in 38.0 + 0.0035 + 0.00003 is:
   (a) 38 (b) 38.0035
   (c) 38.00353 (d) 38.0
9. Which of the following is the correct unit for measuring nuclear radii?
   (a) Micron (b) Millimetre
   (c) Angstrom (d) Fermi
10. Given the number: 161 cm; 0.161 cm; 0.0161 cm. The number of signification figure for three number is:
    (a) 3, 4, 5 (b) 3, 3, 3
    (c) 3, 3, 4 (d) 3, 4, 4
11. Prefix giga means
    (a) 10^{-9} (b) 10^9 (c) 10^6 (d) 10^{-6}

Multiple Correct Answers Type

12. Which of the following relationships are wrong?
    (a) 1 atm = 0.1 bar (b) 1 litre = 1 dm^3
    (c) 1 J = 0.239 cal (d) 1 eV = 9.11×10^{-4} J

13. Which of the following numbers have same significant figures?
(a) 0.060 (b) 0.60 (c) 6.0 (d) 60

14. Select the numbers with same significant figures:
(a) 6.02×10^{23} (b) 0.25
(c) 6.60×10^{-34} (d) 1.50

15. Which of the following have same significant figures?
(a) 6.02×10^{23} (b) 7.70×10^{-20}
(c) 7.50 (d) 0.75

16. Which of the following relations are correct?
(a) 1 mm = 133.322 Pa (b) 1 bar = 101325 Pa
(c) 1 litre = 1.056 quarts (d) 1 lb = 4.536 g

Matching Column Type

17. Match the following:

	Column I		Column II
a.	0.006	p.	10^{-15}
b.	femto	q.	3
c.	6.00×10^{-3}	r.	10^9
d.	giga	s.	1
e.	mega	t.	An infinite number
f.	p	u.	10^6

Integer Type

18. A student performs a titration with different burettes and finds titre values of 25.2 mL, 25.25 mL and 25.0 mL. The number of significant figures in the average titre value is...

19. The number of significant figures up to which the result of the following may be expressed is:

$$\frac{(29.4 - 21.4)(1.86 \times 10^3)}{1.78}$$

Comprehension Type

Precision refers to the closeness of a set of values obtained for identical measurement of a quantity. Precision depends on the limitations of measuring devices and the skills with which it is used. However, accuracy refers to the closeness of a single measurement to its true value.

The digits in a properly recorded measurement are known as significant figures. These are meaningful digits in a measured or calculated quantity. The greater the number of significant figures in a reported result, smaller is the uncertainty and greater is the precision. The zeros at the beginning are not counted. The zeros to the right of a decimal point are counted. In the number that do not contain a decimal point. "trailing" zeros may or may not be significant. The purpose of zeros at the end of a number is to convey the correct range of uncertainty.

20. If repeated measurement give values close to one another, the number is:
(a) surely precise
(b) surely accurate
(c) surely precise and accurate
(d) all of these are correct

21. The number of significant figures in a measured number contains how many uncertain number of digits?
(a) zero (b) 1
(c) 2 (d) cannot be predicted

22. If we add 269.2 and 2.256, we get the answer as 298.456 g. The number of significant figures in the result are:
(a) 6 (b) 5 (c) 4 (d) 3

23. In which of the following numbers, all the zeros are not significant?
(a) 0.0010 (b) 0.00100
(c) 0.001000 (d) 0.001

Answers Key

Subjective Type

1. (i) 1.49×10^{11} m (ii) 1.57 m
(iii) 44 ms^{-1} (iv) 0.74×10^{-10} m or 7.4×10^{-11} m
(v) 319.15 K (vi) 68.1 kg

2. (i) 0.0561 (ii) 0.3×10^{-4}
(iii) 325.23 (iv) 2.97×10^3
(v) 104

3. 9.27 g/cm^3

Single Correct Answer Type

4. (d) **5.** (c) **6.** (b) **7.** (a) **8.** (d)
9. (d) **10.** (b) **11.** (b)

Multiple Correct Answers Type

12. (a, d) **13.** (a, b, c, d) **14.** (a, c, d)
15. (a, b, c) **16.** (a, c)

Matching Column Type

17. (a → s), (b → p), (c → q), (d → r), (e → u), (f → t)

Integer Type

18. (3) **19.** (2)

Comprehension Type

20. (a) **21.** (b) **22.** (c) **23.** (d)

DPP 1.2

Laws of Chemical Combination, Dalton's Theory, Various Types of Masses

Subjective Type

1. The following data are obtained when dinitrogen and dioxygen react together to form different compounds:

	Mass of dinitrogen	Mass of dioxygen
(i)	14 g	16 g
(ii)	14 g	32 g
(iii)	28 g	32 g
(iv)	28 g	80 g

2. Phosphorus and chlorine form two compounds. The first compound contains 22.54% by mass of phosphorus and 77.46% by mass of chlorine. In the second compound the percentages are 14.88 for phosphorus and 85.12 for chlorine. Show that these data are consistent with the law of multiple proportions.

3. Two oxides of a metal contain 27.6% and 30% of oxygen respectively. If the formula of the first compound is M_3O_4, find the formula of the second compound.

4. The average mass of one gold atom in a sample of naturally occurring gold is 3.257×10^{-22} g. Use this to calculate the molar mass of gold.

Single Correct Answer Type

5. There are two common oxides of Sulphur, one of which contains 50% O_2 by weight, the other almost exactly 60%. The weights of sulphur which combine with 1 g of O_2 (fixed) are in the ratio of
   (a) 1 : 1
   (b) 2 : 1
   (c) 2 : 3
   (d) 3 : 2

6. Iron forms two oxides, in first oxide 56 gram. Iron is found to be combined with 16 gram oxygen and in second oxide 112 gram iron is found to be combined with 48 gram oxygen. This data satisfy the law of
   (a) Conservation of mass
   (b) Reciprocal proportion
   (c) Multiple proportion
   (d) Combining volume

7. When 10 mL of propane (gas) is combusted completely, volume of $CO_2(g)$ obtained in similar condition is
   (a) 10 mL
   (b) 20 mL
   (c) 30 mL
   (d) 40 mL

8. In an ionic compound moles ratio of cation to anion is 1 : 2. If atomic masses of metal and non-metal respectively are 138 and 19, then correct statement is
   (a) molecular mass of compound is 176
   (b) formula mass of compound is 176
   (c) formula mass of compound is 157
   (d) molecular mass of compound is 157

9. Two substances I and II of carbon and oxygen have respectively 72.73% and 47.06% oxygen. Hence, they follow
   (a) law of multiple proportion
   (b) law of reciprocal proportion
   (c) law of definite proportion
   (d) law of conservation of mass

10. H_2S contains 97.11% sulphur; SO_2 contains 50% oxygen and H_2O contains 11.11% hydrogen. Thus,
    (a) law of multiple proportion is followed
    (b) law of reciprocal proportion is followed
    (c) law of conservation of mass is followed
    (d) all of the above

11. CO, CO_2, C_2O_3 follow
    (a) law of definite proportion
    (b) law of multiple proportion
    (c) law of conservation of mass
    (d) all of the above

12. Two oxides of a metal contain 50% and 40% metal M respectively. If the formula of the first oxide is MO_2, the formula of the second oxide will be
    (a) MO_2
    (b) MO_3
    (c) M_2O
    (d) M_2O_5

13. If isotopic distribution of C^{12} and C^{14} is 98.0% and 2.0% respectively, then the number of C^{14} atoms in 12 g of carbon is
    (a) 1.032×10^{22}
    (b) 1.20×10^{22}
    (c) 5.88×10^{23}
    (d) 6.02×10^{23}

Multiple Correct Answers Type

14. One of the statements of Dalton's atomic theory is given below:
    "Compounds are formed when atoms of different elements combine in a fixed ratio"
    Which of the following laws is/are not related to this statement?
    (a) Law of conservation of mass

(b) Law of definite proportions
(c) Law of multiple proportions
(d) Avogadro's hypothesis

15. Which of the statements are true?
(a) Law of constant composition is true for all types of compounds.
(b) Molar volume of a gas at standard conditions is 22.4 L
(c) Vapour density of a gas is twice of its molecular mass
(d) Atomic masses of most elements are fractional.

16. Which of the following statements are correct?
(a) French chemist A. Lavoisier is called the father of chemistry and proposed the law of conservation of mass.
(b) French chemist Joseph Proust proposed the law of definite proportions.
(c) Dalton proposed the law of multiple proportions.
(d) Richter proposed the law of reciprocal proportions.

17. Which of the statements are true about the law of chemical combination?
(a) Potassium combines with two isotopes of chlorine (^{35}Cl and ^{37}Cl) to form two samples of KCl. Their formation follows the law of definite composition.
(b) Different proportions of oxygen in the various oxides of sulphur prove the law of multiple proportions.
(c) H_2O and H_2S contain 11.11% hydrogen and 5.88% hydrogen, respectively, whereas SO_2 contains 50% sulphur. The above data prove the law of reciprocal proportions.
(d) In the decomposition of NH_3, ($2NH_3 \xrightarrow{\Delta} N_2 + 2H_2$), the ratio of volumes of NH_3, N_2 and H_2 is 2 : 1 : 3. The above data proves the Gay Lussac law.

18. Which of the following pair of compounds illustrate the law of multiple proportions?
(a) SO_2 and SO_3 (b) NO_2 and N_2O
(c) MgO and $Mg(OH)_2$ (d) NO and N_2O_5

19. On amu scale, atomic weight of Ca is 40. If one u is redefined, which of the following would be correct?
(a) Atomic weight of Ca is 20 if one u is defined as 1/6th of weight of an atom of C-12
(b) Atomic weight of Ca is 60 if one u is defined as 1/15th of weight of an atom of C-12
(c) Atomic weight of Ca is 70 if one u is defined as 1/21st of weight of an atom of C-12
(d) Atomic weight of Ca is 80 if one u is defined as 1/30th by weight of an atom of C-12

Matching Column Type

20. Match the following:

	Column I		Column II
a.	On decomposition 50% increase in volume at the pressure	p.	NH_3
b.	On decomposition 100% increase in volume at same temperature and pressure	q.	HI
c.	On decomposition no change in volume at the same temperature and pressure	r.	O_3
d.	Gases highly soluble in water	s.	$COCl_2$
		t.	HCl

Integer Type

21. If 6.1 g of $NaHCO_3$ are added to 14.9 g of CH_3COOH solution, the residue is found to weigh 16.0 g. What is the mass of CO_2 released in the reaction?

22. A sample of chlorine has only two isotopes, Cl^{35} and Cl^{37} and its average atomic weight is 35.82. The percentage abundance of isotope Cl^{37} in the given sample is $x \times 10^1$ where x is....

Comprehension Type

Three isotopes of Mg is available in nature. They are $^{24}_{12}Mg$, $^{25}_{12}Mg$, $^{26}_{12}Mg$

The relative abundance of the isotopes are as follows:

Isotopes	Relative abundance
$^{24}_{12}Mg$	80%
$^{25}_{12}Mg$	5%
$^{26}_{12}Mg$	15%

23. Which isotope has maximum number of atoms per gram of each?
(a) $^{24}_{12}Mg$ (b) $^{25}_{12}Mg$
(c) $^{26}_{12}Mg$ (d) equal

24. Number of neutrons are highest in
(a) $^{24}_{12}Mg$ (b) $^{25}_{12}Mg$
(c) $^{26}_{12}Mg$ (d) equal

25. Average atomic mass of Mg is approximately equal to
(a) 25.0 (b) 24.3 (c) 25.2 (d) 25.8

Answers Key

Subjective Type

1. 2 : 4 : 2 : 5
2. 1 : 1.66 or 3 : 5 (approx.)
3. M_2O_3
4. Molar mass = $N_A \times 3.257 \times 10^{-22}$ g

Single Correct Answer Type

5. (d) **6.** (c) **7.** (c) **8.** (b) **9.** (a)
10. (b) **11.** (b) **12.** (b) **13.** (b)

Multiple Correct Answers Type

14. (a, d) **15.** (d)

16. (a, b, c, d) **17.** (b, c, d)
18. (a, b, d) **19.** (a, c)

Matching Column Type

20. (a $\rightarrow$ r), (b $\rightarrow$ p, s), (c $\rightarrow$ q, t), (d $\rightarrow$ p, q, s, t)

Integer Type

21. (5) **22.** (6)

Comprehension Type

23. (a) **24.** (c) **25.** (b)

DPP 1.3

Mole Concept, Empirical Formula and Molecular Formula

Subjective Type

1. A drug marijuana owes its activity to terahydro cannabinol, which contains 70% as many as carbon atoms as hydrogen atoms and 15 times as many hydrogen atoms as oxygen atoms. The number of moles in a gram of terahydro cannabinol is 0.00318. Determine its molecular formula.
2. From 200 mg of CO_2, 10^{21} molecules are removed. How many g and mole of CO_2 are left?
3. The density of O_2 at NTP is 1.429 g/L. Calculate the standard molar volume of gas.
4. A gaseous alkane is exploded with oxygen. The volume of O_2 for complete combustion to CO_2 formed is in the ratio of 7 : 4. Deduce molecular formula of alkane.
5. A crystalline salt on heating becomes anhydrous and loses 45.6% of its weight. Its percentage composition is Al—10.50%, K—15.1%, S—24.96%, and O—49.92%. What is the formula of the anhydrous and crystalline salt?

Single Correct Answer Type

6. Insulin contains 3.4% sulphur. What will be the minimum molecular weight of insulin?
   (a) 94.176
   (b) 1884
   (c) 941.176
   (d) 976
7. The volume occupied by 7.23×10^{23} molecules of carbon dioxide and 3.01×10^{23} molecules of Argon at 0°C and 1 atm pressure is
   (a) 38 mL
   (b) 3.80 L
   (c) 3.8×10^4 mL
   (d) 3.8×10^3 mL
8. A given sample of pure compound contains 9.81 g of Zn, 1.8×10^{23} atoms of chromium, and 0.60 mol of oxygen atoms. What is the simplest formula?
   (a) $ZnCr_2O_7$
   (b) $ZnCr_2O_4$
   (c) $ZnCrO_4$
   (d) $ZnCrO_6$
9. A sample of aluminium has a mass of 54.0 g. What is the mass of the same number of magnesium atoms?
   (a) 12 g
   (b) 24 g
   (c) 48 g
   (d) 96 g
10. Four 1 – 1 litre flasks are separately filled with the gases H_2, He, O_2 and O_3 at the same temperature and pressure. The ratio of total number of atoms of these gases present in different flask would be:
    (a) 1 : 1 : 1 : 1
    (b) 1 : 2 : 2 : 3
    (c) 2 : 1 : 2 : 3
    (d) 3 : 2 : 2 : 1
11. Under the same conditions, two gases have the same number of molecules. They must
    (a) be noble gases
    (b) have equal volume
    (c) have a volume of 22.4 dm^3 each
    (d) have an equal number of atoms
12. The vapour density of a gas A is twice that of a gas B. If the molecular weight of B is M, the molecular weight of A will be:
    (a) M
    (b) 2 M
    (c) 3 M
    (d) $\frac{M}{2}$
13. The atomic weight of two elements *A* and *B* are 40 and 80 respectively. If *x* g of *A* contains *y* atoms, how many atoms are present in 2*x* g of *B*?
    (a) $\frac{y}{2}$
    (b) $\frac{y}{4}$
    (c) *y*
    (d) 2*y*

Multiple Correct Answers Type

14. Which is/are correct statements about 1.7 g of NH_3?
    (a) It contains 0.3 mol H-atom
    (b) It contains 2.408×10^{23} atoms
    (c) Mass % of hydrogen is 17.65%
    (d) Vapour density of NH_3 is 17
15. Which of the following has same percentage of carbon as in ethane?
    (a) 2-Butene
    (b) Cyclohexane
    (c) Cyclohexene
    (d) 2-Methyl but-2-ene
16. 2.0 g of a tri-atomic gaseous element was found to occupy a volume of 448 mL at 76 cm of Hg and 273 K. The mass of its atom is
    (a) 33.3 amu
    (b) 5.53×10^{-23} g
    (c) 33.3 g
    (d) 5.53 amu
17. You have given 4.25 g NH_3(g).
    Given: at. wt. of N–14 ; H –1
    Which of the following is/are correct regarding above NH_3?
    (a) It contains 0.25 mole of NH_3
    (b) It contains 0.75 mole of H-atom
    (c) It contains total of 1.0 mole of N and H atoms.
    (d) It contains approximately 1.5×10^{23} molecules of NH_3
18. Which of the following contains same number of molecules?
    (a) 1 g of O_2, 2 g of SO_2
    (b) 1 g of CO_2, 1 g of N_2O

(c) 112 mL of O_2 at S.T.P, 224 mL of He at 0.5 atm and 273 K

(d) 1 g of oxygen, 1 g of ozone

19. For 3 mole of ammonia (g), which of the following is true?

(a) It contains 12 N_A atoms

(b) Volume at S.T.P. is 67.2 litre

(c) No. of molecules is 1.80×10^{24}

(d) Total no. of electrons is 1.80×10^{25}

Matching Column Type

20. The recommended daily dose is 17.6 milligrams of vitamin C (ascorbic acid) having formula $C_6H_8O_6$.

Match the following. Given: $N_A = 6 \times 10^{23}$

	Column I		Column II
a.	O-atoms present	p.	10^{-4} mole
b.	Moles of vitamin C in 1 g of vitamin C	q.	5.68×10^{-3}
c.	Moles of vitamin C should be consumed daily	r.	3.6×10^{20}

Integer Type

21. The hydrated salt $Na_2SO_4 \cdot nH_2O$ undergoes 50.3% loss in weight on heating and become anhydrous. The value of '*n*' will be ____.

22. How many N_A electrons is present in 5.1 g NH_3?

23. If a protein has 0.07% Fe (M = 56) by weight as the only metal, its molar mass would be at least M × 10^4 g. Here M is … .

Comprehension Type

Passage 1:

A crystalline hydrated salt on being rendered anhydrous loses 45.6% of its weight.

The percentage composition of anhydrous salt is: Al = 10.5%, K = 15.1%, S = 24.8% and oxygen = 49.6%

[Molar mass are: Al = 27, K = 39, S = 32].

24. What is the empirical formula of the salt?

(a) $K_2AlS_2O_7$ (b) $K_2Al_2S_2O_7$

(c) $KAlS_2O_8$ (d) $K_3AlS_2O_{12}$

25. What is the empirical formula of the hydrated salt?

(a) $K_2AlS_2O_7.10H_2O$ (b) $K_2Al_2S_2O_7.16H_2O$

(c) $K_3AlS_2O_{12}.8H_2O$ (d) $KAlS_2O_8.12H_2O$

Passage 2:

The term mole first used by Ostwald in 1896 refers for the ratio of mass of a substance in g and its molecular weight. 1 mole of a gaseous compound occupies 22.4 litre at NTP and contains 6.23 × 10^{23} molecules of gas.

26. The vapour density of a mixture containing NO_2 and N_2O_4 is 38.3 at 27°C. The moles of NO_2 in 100 mole mixture is

(a) 33.48 (b) 53.52 (c) 38.3 (d) 76.6

27. The maximum number of atoms present are in

(a) 4 g He (b) 4 g O_2 (c) 4 g O_3 (d) 4 g H_2O_2

Answers Key

Subjective Type

1. $C_{21}H_{30}O_2$ **2.** 2.88×10^{-3}

3. 22.39 litre mol^{-1} **4.** C_2H_6

5. $K \cdot Al \cdot S_2O_8 \cdot 12H_2O$

Single Correct Answer Type

6. (c) **7.** (c) **8.** (b) **9.** (c) **10.** (c)

11. (b) **12.** (b) **13.** (c)

Multiple Correct Answers Type

14. (a, b, c) **15.** (a, b, d)

16. (a, b) **17.** (a, b, c, d)

18. (a, b, c) **19.** (a, b, c, d)

Matching Column Type

20. (a → r), (b → q), (c → p)

Integer Type

21. (8) **22.** (3) **23.** (8)

Comprehension Type

24. (c) **25.** (d) **26.** (a) **27.** (a)

DPP 1.4

Stoichiometry and Limiting Reactant

Subjective Type

1. A compound which contains one atom of X and two atoms of Y for each three atoms of Z is made by mixing 5.00 g of X, 1.15 x 10^{23} atoms of Y and 0.03 mole of Z atoms. Given that only 4.40 g of compound results. Calculate the atomic weight of Y if the atomic weight of X and Z are 60 and 80 a.m.u. respectively.
2. Calculate the mass of FeO produced from 2 g VO and 5.75 g of Fe_2O_3. Also report the limiting reagent.

$$VO + Fe_2O_3 \longrightarrow FeO + V_2O_5$$

3. Carbon disulphide, CS_2, can be made from by-product of SO_2. The overall reaction is

$$5C + 2SO_2 \longrightarrow CS_2 + 4CO$$

How much CS_2 can be produced from 440 kg of waste SO_2 with 60 kg of coke if the SO_2 conversion is 80%?

4. What weight of zinc would be required to produce enough hydrogen to reduce completely 8.5 g of copper oxide to copper?
5. 200 mL of any gas at N.T.P was heated with tin. Tin got converted into stannous sulphide and hydrogen was left. This hydrogen when passed over hot CuO, produced 0.162 g of H_2O. If the vapour density of the gas is 17, find its formula.

Single Correct Answer Type

6. Calculate the amount of Ni needed in the Mond's process given below.

$$Ni + 4CO \longrightarrow Ni(CO)_4$$

If CO used in this process is obtained through a process, in which 6 g of carbon is mixed with 44 g CO_2.

$$Ni + 4CO \longrightarrow Ni(CO)_4$$

(a) 14.675 (b) 29 g (c) 58 g (d) 28 g

7. Equal weight of 'X' (At. wt. = 36) and 'Y' (At. wt. = 24) are reacted to form the compound X_2Y_3. Then:
   (a) X is the limiting reagent
   (b) Y is the limiting reagent
   (c) No reactant is left over and mass of X_2Y_3 formed is double the mass of 'X' taken
   (d) None of these
8. In a certain operation 358 g of $TiCl_4$ is reacted with 96 g of Mg. Calculate % yield of Ti if 32 g of Ti is actually obtained [At. wt. = 48, Mg = 24]
   (a) 35.38% (b) 66.6%
   (c) 100% (d) 60 %
9. NX is produced by the following step of reactions

$$M + X_2 \longrightarrow MX_2$$
$$3MX_2 + X_2 \longrightarrow M_3X_8$$
$$M_3X_8 + N_2CO_3 \longrightarrow NX + CO_2 + M_3O_4$$

How much M (metal) is consumed to produce 206 g of NX? (Take at. wt. of M = 56, N = 23, X = 80)

(a) 42 g (b) 56 g (c) $\frac{14}{3}$ g (d) $\frac{7}{4}$ g

10. The following process has been used to obtain iodine from oil-field brines in California.

$$NaI + AgNO_3 \longrightarrow AgI + NaNO_3$$
$$2AgI + Fe \longrightarrow FeI_2 + 2Ag$$
$$2FeI_2 + 3Cl_2 \longrightarrow 2FeCl_3 + 2I_2$$

How many grams of $AgNO_3$ are required in the first step for every 254 kg I_2 produced in the third step?

(a) 340×10^4 (b) 340×10^3
(c) 34×10^3 (d) 34×10^5

11. If 20.0 g of $CaCO_3$ is treated with 20.0 g of HCl, how many grams of CO_2 can be produced according to the reaction:

$$CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

(a) 8.80 g (b) 7.70 g (c) 8.00 g (d) 7.20 g

Multiple Correct Answers Type

12. 2.4 g of pure Mg (at. mass 24) is dropped in 100 mL of 1N HCl. What is true?
    (a) 1.122 L of hydrogen is produced at S.T.P.
    (b) 0.01 mol of magnesium is behind
    (c) 0.1 mol of Mg^+ ions are formed in solution
    (d) HCl is the limiting reagent
13. $A + B \rightarrow A_3B_2$ (unbalanced)
    $A_3B_2 + C \rightarrow A_3B_2C_2$ (unbalanced)
    Above two reactions are carried out by taking 3 moles each of A and B and one mole of C. Then which option is/are correct?
    (a) 1 mole of $A_3B_2C_2$ is formed

(b) 1/2 mole of $A_3B_2C_2$ is formed
(c) 1/2 mole of A_3B_2 is formed
(d) 1/2 mole of A_3B_2 is left finally

14. If 27 g of carbon is mixed with 88 g of oxygen and is allowed to burn to produce CO_2, then:
(a) Oxygen is the limiting reagent
(b) Volume of CO_2 gas produced at NTP is 50.41 L
(c) C and O combine in mass ratio 3 : 8
(d) Volume of unreacted O_2 at STP is 11.2 L

15. Which of the following statements is/are correct?
A mixture containing 64.0 g H_2 and 64.0 g O_2 is ignited so that water is formed as follows:

$$2H_2 + O_2 \longrightarrow 2H_2O$$

(a) H_2 is the limiting reagent
(b) O_2 is the limiting reagent
(c) The reaction mixture contains 72.0 g of H_2O and 56.0 g of unreacted H_2.
(d) The reaction mixture contains 56.0 g of H_2O and 72.0 g unreacted H_2.

16. Which of the following is/are correct?
The following reaction occurs:

$$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + CO_2 + H_2O$$

106.0 g of Na_2CO_3 reacts with 109.5 g of HCl.
(a) The HCl is in excess
(b) 117.0 g of NaCl is formed
(c) The volume of CO_2 produced at 1 bar and 273 K is 22.7 L.
(d) The volume of CO_2 produced at 1 bar and 298 K is 24.7 L.

Matching Column Type

17. Match the following:

	Column I		Column II
a.	$\underset{1g}{2H_2} + \underset{1g}{O_2} \rightarrow 2H_2O$	p.	0.56 g of CaO
b.	$\underset{1g}{N_2} + \underset{1g}{3H_2} \rightarrow 2NH_3$	q.	1.333 g
c.	$\underset{1g}{CaCO_3} \rightarrow CaO + CO_2$	r.	1.125 g
d.	$\underset{1g}{2H_2} \rightarrow \underset{1g}{C} + CH_4$	s.	1.214 g

Integer Type

18. 10 g of hydrogen and 64 g of oxygen were filled in a steel vessel and exploded. Amount of water produced in this reaction will be ... .

19. If 5 g H_2 is mixed with 14 g of nitrogen for the following reaction:

$$N_2 + 3H_2 \rightarrow 2NH_3$$

At the end, mass of H_2 left unreacted is ... .

Comprehension Type

Cis platin, an anticancer agent used for the treatment of solid tumors, is prepared by the reaction of ammonia with potassium tetrachloroplatinate.

$$K_2PtCl_4 + 2NH_3 \rightarrow [Pt(NH_3)_2Cl_2]\ 2KCl$$

Cis-platin

Assume that 10 g of K_2PtCl_4 and 10 gm of NH_3 are allowed to react. (K = 39, Pt = 195, Cl = 35.5)

20. Number of moles of K_2PtCl_4 consumed
(a) 0.048 (b) 0.024 (c) 0.012 (d) 0.096

21. Number of moles of NH_3 consumed
(a) 0.048 (b) 0.024 (c) 0.096 (d) 0.192

22. Number of moles of excess reactant which remains unreacted is
(a) 0.024 (b) 0.34 (c) 0.54 (d) 0.56

Answers Key

Subjective Type

1. 70 amu **2.** Fe_2O_3 **3.** 76 kg
4. (i) 0.214 g (ii) 6.955 g
5. H_2

Single Correct Answer Type

6. (a) **7.** (c) **8.** (a) **9.** (a) **10.** (b)
11. (a)

Multiple Correct Answers Type

12. (a, d) **13.** (b, d)
14. (b, c, d) **15.** (b, c)
16. (a, b, c, d)

Matching Column Type

17. (a → r), (b → s), (c → p), (d → q)

Integer Type

18. (4) **19.** (2)

Comprehension Type

20. (b) **21.** (a) **22.** (c)

DPP 1.5

Mole Concept in Solutions

Subjective Type

1. (a) How much $Ca(NO_3)_2$ in mg must be present in 50 mL of a solution with 2.35 ppm of Ca? (d = 1 g/cc)
   (b) What is the molarity of NaCl solution having 1.52 ppm of Na and the solution density is 1.0 g/cm^3?
2. Calculate the ionic strength (in g/litre)of a solution containing 0.2 M NaCl and 0.1 M Na_2SO_4.
3. What volume of water should be added to 50 mL of HNO_3 having density 1.5 g mL^{-1} and 63.0% by weight to have one molar solution.
4. 5 g of K_2SO_4 was dissolved in 250 mL of solution. How many mL of this solution should be used so that 2.33 g of $BaSO_4$ may be precipitated from $BaCl_2$ solution.

$$K_2SO_4 + BaCl_2 \longrightarrow BaSO_4 + 2KCl$$

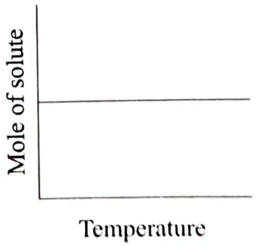
5. In a solution, the concentration of $CaCl_2$ is 5 M and that of $MgCl_2$ is 5 m. The specific gravity of solution is 1.05. Calculate the concentration of Cl^- in the solution in terms of molarity.

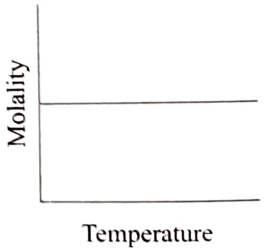
Single Correct Answer Type

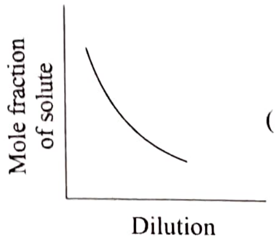
6. The mole fraction of a given sample of I_2 in C_6H_6 is 0.2. The molality of I_2 in C_6H_6 is:
   (a) 0.32 (b) 3.2 (c) 0.032 (d) 0.48
7. 125 mL of 10% NaOH (w/V) is added to 125 mL of 10% HCl (w/V). The resultant solution becomes
   (a) alkaline (b) strongly alkaline
   (c) acidic (d) neutral
8. The molarity of the solution containing 2.8% (mass/volume) solution of KOH is: (Given atomic mass of K = 39) is:
   (a) 0.1 M (b) 0.5 M (c) 0.2 M (d) 1 M
9. If 500 mL of 1 M solution of glucose is mixed with 500 mL of 1 M solution of glucose. The final molarity of solution will be:
   (a) 1 M (b) 0.5 M (c) 2 M (d) 1.5 M
10. The molality of a sulphuric acid solution is 0.2. calculate the total weight of the solution having 1000 g of solvent.
   (a) 1000 g (b) 1098.6 g
   (c) 980.4 g (d) 1019.6 g
11. What volumes should you mix of 0.2 M NaCl and 0.1 M $CaCl_2$ solution so that in resulting solution the concentration of positive ion is 40% lesser than concentration of negative ion. Assuming total volume of solution 1000 mL.
   (a) 400 mL NaCl, 600 mL $CaCl_2$
   (b) 600 mL NaCl, 400 mL $CaCl_2$
   (c) 800 mL NaCl, 200 mL $CaCl_2$
   (d) None of these

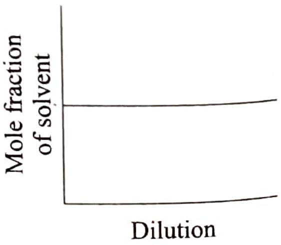
Multiple Correct Answers Type

12. 100 mL of 0.8 M NaOH are used to neutralised 100 mL solution obtained by passing 2.70 g SO_2Cl_2 in water. Select the correct statement:
   (a) The solution of SO_2Cl_2 has 0.2 M H_2SO_4 and 0.4 M HCl
   (b) The volume ratio of NaOH used for H_2SO_4 and HCl is 1 : 2
   (c) The volume ratio of NaOH used for H_2SO_4 and HCl is 1 : 1
   (d) Molarity of SO_2Cl_2 solution is 0.1 M
13. Which one are correct about the solution that contains 3.42 ppm $Al_2(SO_4)_3$ and 1.42 ppm Na_2SO_4?
   (a) $[Al^{3+}] = [Na^+]$
   (b) $[SO_4^{2-}] = [Na^+] = [Al^{3+}]$
   (c) $[SO_4^{2-}] = [Na^+] + [Al^{3+}]$
   (d) $[SO_4^{2-}] = [Na^+]$
14. Which of the following graphs correctly represents the variations?

(a)


(b)


(c)


(d)


15. Which of the following concentration are correct for 13 mass percent of sulphuric acid (density : 1.09 g mL^{-1})?
(a) 1.443 M
(b) 1.625 M
(c) 1.625 mol kg^{-1}
(d) 1.525 mol kg^{-1}

16. 1 mole BaF_2 + 1 mole $H_2SO_4 \longrightarrow$ Resulting mixture
will be neutralized by
(a) 2 mol of KOH
(b) 1 mol of $Ca(OH)_2$
(c) 4 mol of KOH
(d) 2 mole of NaOH

Matching Column Type

17. Match the reactions given in Column I with molarities given in Column II:

	Column I		Column II
a.	What molar concentration of $K_4[Fe(CN)_6]$ should be used so that 40 mL of a solution titrates 196.2 mg Zn (dissolved) by forming $K_2Zn_3[Fe(CN)_6]_2$. (Atomic weight Zn = 65.4 g mol^{-1})	p.	0.25 M
b.	40.0 mL of Na_2SO_4 solution is treated with an excess of $BaCl_2$. If the mass of the precipitated $BaSO_4$ is 2.33 g, the molarity of the Na_2SO_4 solution is (Mw of $BaSO_4$ = 233 g mol^{-1}) $BaCl_2 + Na_2SO_4 \longrightarrow BaSO_4 + 2NaCl$	q.	0.05 M
c.	A sample of solution containing 116 mg of Th^{+} requires 50.0 mL of $H_2C_2O_4$ to precipitate $Th(C_2O_4)_2$. $Th^{4+} + 2C_2O_4^{2-} \longrightarrow Th(C_2O_4)_2$ What is the molarity of $H_2C_2O_4$ (Atomic weight of Th = 232 g)?	r.	0.02 M
d.	10 mL of 0.5 M $AgNO_3$ was required to react exactly with 100 mL solution of NaCN. $Ag^{\oplus} + 2CN^{\ominus} \longrightarrow Ag(CN)_2^{\ominus}$ What is the molarity of NaCN?	s.	0.1 M

Integer Type

18. How many mL of a solution of concentration 100 mg Co^{2+} per mL is needed to prepare 10 mL a solution of concentration 20 mg Co^{2+} per mL?

19. HCl gas is passed into water, yielding a solution of density 1.095 g mL^{-1} and containing 30% HCl by weight. Calculate the molarity of the solution.

20. How many litres of 2M H_3AsO_4 require to prepare 4 litre of 1 M H_3AsO_4?

Comprehension Type

HNO_3 used as a reagent has specific gravity of 1.42 g mL^{-1} and contains 70% by strength HNO_3.

21. Normality of acid is:
(a) 16.78
(b) 15.78
(c) 14.78
(d) 17.78

22. Volume of acid that contains 63 g pure acid is
(a) 100 mL
(b) 40.24 mL
(c) 63.38 mL
(d) 70.68 mL

23. Volume of water required to make 1 N solution from 2 mL conc. HNO_3 is
(a) 29.56 mL
(b) 30.56 mL
(c) 28.56 mL
(d) 31.56 mL

Answers Key

Subjective Type

1. (a) 0.48 mg (b) 6.6087×10^{-5} M NaCl
2. 9.6 g/L
3. 700 mL
4. 87 mL
5. 13.36 in 1 litre solution

Single Correct Answer Type

6. (b) **7.** (c) **8.** (b) **9.** (a) **10.** (d)
11. (d)

Multiple Correct Answers Type

12. (a, c) **13.** (a, c) **14.** (a, b, c) **15.** (a, d)
16. (a, b, d)

Matching Column Type

17. (a → q), (b → p), (c → r), (d → s)

Integer Type

18. (2) **19.** (9) **20.** (2)

Comprehension Type

21. (b) **22.** (c) **23.** (a)

DPP 1.6

Redox Titration and Stoichiometry in Various Types of Titrations

Subjective Type

1. 0.5 g of an impure sample of oxalate was dissolved in water and the solution made to 100 mL. On titration, 10 mL of this solution required 15 mL of N/20 $KMnO_4$ solution. Calculate the percentage of pure oxalate in the sample.
2. Both $Cr_2O_7^{2-}$(aq) and MnO_4^-(aq) can be used to titrate Fe^{2+}(aq). If in a given titration, 24.50 cm^3 of 0.1 M $Cr_2O_7^{2-}$ were used, then what volume of 0.1 M MnO_4^- solution would have been used for the same titration?
3. An impure sample of $CaCO_3$ that has moist clay as impurity on heating loses 14.5% of its weight of water. 5 g of the sample shows a loss in weight by 1.507 g. Calculate the percentage of $CaCO_3$ in the sample.
4. Calculate the weight of quick lime and soda ash required to soften one million litres of hard water containing dissolved salts as shown below:
   $Ca(HCO)_3$ = 48.6 ppm; $MgCl_2$ = 19.0 ppm; $CaSO_4$ = 68.0 ppm; SiO_2 = 15.2 ppm
5. A mixture contains $NaNO_3$, $AgNO_3$ and some impurity. 3.1 g of the mixture was heated and the gases released were passed in pyrogalol. The weight of pyrogalol increased by 0.208 g. The residue left needs—for complete reaction—25 mL of N/10 HCl. How much $NaNO_3$ and $AgNO_3$ is present in the mixture?
6. A mixture contains 20 g of $NaHCO_3$, 20 g of Na_2CO_3 and 20 g of NaOH in a litre. 55 mL of the mixture is titrated with NHCl. Calculate the titre value when
   (a) phenolphthalein is used first
   (b) methyl orange is added after first end point
   (c) methyl orange is added from the beginning.
7. A solution of $Na_2S_2O_3$ is standardized iodometrically against 0.334 g of pure $KBrO_3$ (converted to Br^-) requiring 40 mL $Na_2S_2O_3$ solution. What is the molarity of $Na_2S_2O_3$ solution? (Molar mass of $KBrO_3$ = 167 g mol^{-1})
8. A 0.5 sample of an iron-containing mineral, mainly in the form of $CuFeS_2$, was reduced suitably to convert all the ferric iron into ferrous form and was obtained as a solution. In the absence of any interfering matter, the solution required 40 mL of 0.01 M $K_2Cr_2O_7$ solution for titration. Calculate the percentage of $CuFeS_2$ in the mineral.
9. For estimating ozone in the air, a certain volume of air is passed through an alkaline KI solution when O_2 is evolved and Iodide is oxidised to Iodine. When such a solution is acidified, free iodine is evolved which can be titrated with standard $Na_2S_2O_3$ solution. In an experiment 10 L of air at 1 atm and 27°C were passed through an alkaline KI solution, and at the end, the iodine was entrapped in a solution which on titration as above required 1.5 mL of 0.01 N $Na_2S_2O_3$ solution. Calculate volume percentage of ozone in the sample
10. A sample of fuming sulphuric acid containing H_2SO_4, SO_3 and SO_2 weighing 1.00 g is found to require 23.47 mL of 1.00 M alkali (NaOH) for neutralisation. A separate sample shows the presence of 1.50% SO_2. Find the percentage of "free" SO_3, H_2SO_4 and "combined" SO_3 in the sample.

Single Correct Answer Type

11. Number of mole of $K_2Cr_2O_7$ in acidic medium required to oxidise one mole of Cu_3P to $CuSO_4$ and H_3PO_4 is:
    (a) 11/6　(b) 6/11
    (c) 3/5　(d) 5/3
12. In Fe^{2+} *vs* MnO_4^- titration, HNO_3 is not used because it:
    (a) oxidises Mn^{2+}　(b) reduces MnO_4^-
    (c) oxidises Fe^{2+}　(d) reduces Fe^{3+} formed
13. 0.5 g of fuming H_2SO_4 (oleum) is diluted with water. This solution is completely neutralised by 26.7 mL of 0.4 N NaOH. The percentage of free SO_3 in the sample is
    (a) 30.6%　(b) 40.6%
    (c) 20.6%　(d) 50%
14. 34 g of hydrogen peroxide is present in 1120 mL of solution. This solution is called
    (a) 10 volume solution　(b) 20 volume solution
    (c) 30 volume solution　(d) 32 volume solution
15. A 5 mL solution of H_2O_2 liberates 0.508 gm of Iodine from an acidified KI solution. What is the volume strength of the H_2O_2 solution?
    (a) 2.2%　(b) 3.8%
    (c) 4.48%　(d) None of these
16. The volume of 0.25 M H_3PO_3 required to neutralise 25 mL of 0.03 M $Ca(OH)_2$ is
    (a) 1.32 mL　(b) 3 mL
    (c) 26.4 mL　(d) 2.0 mL
17. 50 mL of a solution containing 1 g each of Na_2CO_3, $NaHCO_3$ and NaOH was titrated with 1 N HCl. What will

be the titre reading when only phenolphthalein is used as indicator?

(a) 35 mL (b) 32.5 mL
(c) 24.5 mL (d) 34.4 mL

18. A mixture of 0.02 mole of $KBrO_3$ and 0.01 mole of KBr was treated with excess of KI and acidified. The volume of 0.1 M $Na_2S_2O_3$ solution required to consume the liberated iodine will be:

(a) 1000 mL (b) 1200 mL
(c) 1500 mL (d) 800 mL

19. Which of the following are not valid reactions for iodometric titrations?

(a) $O_3 + 2I^- + 2H^+ \longrightarrow O_2 + I_2 + H_2O$
(b) $8HNO_3 + 6I^- \longrightarrow 6NO_3^- + 2NO + 2I_2 + 4H_2O$
(c) $CuSO_4 + 2KI \longrightarrow Cu_2I_2 + I_2 + K_2SO_4$
(d) $Na_2S_2O_3 + I_2 \longrightarrow Na_2S_4O_6 + 2NaI$

Multiple Correct Answers Type

20. 100 mL of 0.1 M $NaHC_2O_4$ is neutralised by V_1 mL of 0.1 M NaOH and V_2 mL of a M $KMnO_4$ separately, then for complete neutralisation:

(a) volume of NaOH required = 200 mL
(b) if M of $KMnO_4$ is 0.1 M then $\frac{V_1}{V_2} = 5 : 1$
(c) if M of $KMnO_4$ is 0.1 M then $V_2 = 20$ mL
(d) if M of $KMnO_4$ is 0.2 M then $V_2 = 2$ mL

21. A mixture of $Na_2C_2O_4$ and $H_2C_2O_4$ requires 100 mL of 0.1 M $KMnO_4$ for complete neutralisation. The same mixture on neutralisation by a base requires 50 mL of 0.2 M NaOH solution. Which of the following are correct?

(a) Mole ratio of $Na_2C_2O_4$ and $H_2C_2O_4 = 4 : 1$
(b) Equivalent ratio of $Na_2C_2O_4$ and $H_2C_2O_4 = 4 : 1$
(c) Mole of $C_2O_4^{2-}$ in mixture $= 25 \times 10^{-3}$
(d) Mole ratio of $Na_2C_2O_4$ and $H_2C_2O_4 = 1 : 4$

22. Reduction of the metal centre in aqueous permanganate ion involves:

(a) 3 electrons in neutral medium
(b) 5 electrons in neutral medium
(c) 3 electrons in alkaline medium
(d) 5 electrons in acidic medium

23. Which of the following samples of reducing agents is/are chemically equivalent to 25 mL of 0.2 N $KMnO_4$ to be reduced to Mn^+ and water?

(a) 25 mL of 0.2 M $FeSO_4$ to be oxidized to Fe^{3+}
(b) 50 mL of 0.1 M H_3AsO_3 to be oxidized to H_3AsO_4
(c) 25 mL of 0.1 M H_2O_2 to be oxidized to H^+ and O_2
(d) 25 mL of 0.1 M $SnCl_2$ to be oxidized to Sn^{4+}

24. In the titration of $K_2Cr_2O_7$ and ferrous sulphate, following data is obtained:
V_1 mL of $K_2Cr_2O_7$ solution of molarity M_1 requires V_2 mL of $FeSO_4$ solution of molarity M_2.
Which of the following relations is/are true for the above titration?

(a) $6M_1V_1 = M_2V_2$ (b) $M_1V_1 = 6M_2V_2$
(c) $N_1V_1 = N_2V_2$ (d) $M_1V_1 = M_2V_2$

25. 0.1 M solution of KI reacts with excess of H_2SO_4 and KIO_3 solutions, according to equation $5I^- + IO_3^- + 6H^+ \longrightarrow 3I_2 + 3H_2O$; which of the following statements is/are correct:

(a) 200 mL of the KI solution reacts with 0.004 mole KIO_3.
(b) 100 mL of the KI solution reacts with 0.006 mole of H_2SO_4.
(c) 0.5 litre of the KI solution produced 0.05 mole of I_2.
(d) Equivalent weight of KIO_3 is equal to $\left(\frac{\text{Molecular weight}}{5}\right)$.

Matching Column Type

26. Match the Column I with Column II:

	Column I		Column II
a.	$Sn^{+2} + MnO_4^-$ (acidic) 3.5 mole 1.2 mole	p.	Amount of oxidant available decides the number of electrons transfer
b.	$H_2C_2O_4 + MnO_4^-$ (acidic) 8.4 mole 3.6 mole	q.	Amount of reductant available decides the number of electrons transfer
c.	$S_2O_3^{-2} + I_2$ 7.2 mole 3.6 mole	r.	Number of electrons involved per mole of oxidant > Number of electrons involved per mole of reductant
d.	$Fe^{+2} + Cr_2O_7^{-2}$ (acidic) 9.2 mole 1.6 mole	s.	Number of electrons involved per mole of oxidant < Number of electrons involved per mole of reductant

Integer Type

27. How many grams of potassium dichromate are required to oxidise 15.2 g of $FeSO_4$ in acidic medium?

28. Determine the volume of M/8 $KMnO_4$ solution required to react completely with 25.0 cm^3 of M/4 $FeSO_4$ solution in acidic medium.

Comprehension Type

Bleaching powder and bleach solution are produced on a large scale and used in several household products. The effectiveness of bleach solution is often measured by iodometry.

Cengage Learning Pvt. Ltd.

29. Bleaching powder contains a salt of an oxoacid as one of its components. The anhydride of that oxoacid is:

(a) Cl_2O (b) Cl_2O_7

(c) ClO_2 (d) Cl_2O_6

30. 25 mL of household bleach solution was mixed with 30 mL of 0.50 M KI and 10 mL of 4 N acetic acid. In the titration of the liberated iodine, 48 mL of 0.25 N $Na_2S_2O_3$ was used to reach the end point. The molarity of the household bleach solution is:

(a) 0.48 M (b) 0.96 M

(c) 0.24 M (d) 0.024 M

Answers Key

Subjective Type

1. 66 **2.** 29.4 cm^3 **3.** 53%

4. 16.8 ppm, 74.2 ppm

5. 1.785 g or 57.58%, 0.2125 g or 6.85%

6. (a) 37.88 mL, (b) 23.47 mL, (c) 61.35 mL

7. 0.3 M **8.** 88.08% **9.** 1.847×10^{-3}

10. 28.89%

Single Correct Answer Type

11. (a) **12.** (c) **13.** (c) **14.** (a) **15.** (c)

16. (b) **17.** (d) **18.** (b) **19.** (b)

Multiple Correct Answers Type

20. (b, c) **21.** (a, b, c)

22. (a, c, d) **23.** (a, c, d)

24. (a, c) **25.** (a, b, d)

Matching Column Type

26. (a → p, r), (b → q, r), (c → p, q, r), (d → q, r)

Integer Type

27. (5) **28.** (10)

Comprehension Type

29. (a) **30.** (c)

DPP 1.7

Equivalent Weight of Some Oxidants and Reductants

Subjective Type

1. Calculate the equivalent mass of each oxidant and reductant in:
   (a) $FeSO_4 + KClO_3 \longrightarrow KCl + Fe_2(SO_4)_3$
   (b) $Na_2SO_3 + Na_2CrO_4 \longrightarrow Na_2SO_4 + Cr(OH)_3$
   (c) $Fe_3O_4 + KMnO_4 \longrightarrow Fe_2O_3 + MnO_2$
   (d) $KI + K_2Cr_2O_7 \longrightarrow Cr^{3+} + 3I_2$
   (e) $Mn^{4+} \longrightarrow Mn^{2+}$
   (f) $NO_3^- \longrightarrow N_2$
   (g) $N_2 \longrightarrow NH_3$
   (h) $Na_2S_2O_3 + I_2 \longrightarrow Na_2S_4O_6 + 2NaI$
   (i) $FeC_2O_4 \longrightarrow Fe^{3+} + CO_2$
2. Dichromate ion in acid solution oxidizes stannous ion as
   $3Sn^{2+} + 14H^+ + Cr_2O_7^{2-} \longrightarrow 3Sn^{4+} + 2Cr^{3+} + 7H_2O$
   (a) If $SnCl_2$ is the source of Sn^{2+}, how many grams of $SnCl_2$ would be contained in 2 litre of 0.1 N solution?
   (b) If $K_2Cr_2O_7$ is source of $Cr_2O_7^{2-}$, what is the normality of solution containing 4.9 g $K_2Cr_2O_7$ in 0.1 litre of solution?
3. Find out the % of oxalate ion in given sample of oxalate salt of which 0.3 g dissolved in 100 mL of water required 90 mL of N/20 $KMnO_4$ for complete oxidation.

Single Correct Answer Type

4. Equivalent mass of Fe_3O_4 and Fe_2O_3 in the change $Fe_3O_4 \longrightarrow Fe_2O_3$ is respectively: (M_1 and M_2 are molar mass of Fe_3O_4 and Fe_2O_4 respectively)
   (a) $M_1, \frac{3M_2}{2}$ (b) $\frac{M_1}{3}, \frac{M_2}{2}$
   (c) $\frac{M_1}{2}, \frac{M_2}{3}$ (d) $M_1, \frac{2M_2}{2}$
5. The number of moles of $KMnO_4$ that will be needed to react with one mole of sulphite ions in acidic solution is:
   (a) 2/5 (b) 3/5
   (c) 4/5 (d) 1
6. When BrO_3^- ion reacts with Br^- ion in acid medium, Br_2 is liberated? The equivalent mass of Br_2 in the reaction is:
   (a) $\frac{5\,M}{3}$ (b) $\frac{3\,M}{5}$ (c) $\frac{4\,M}{6}$ (d) $\frac{5\,M}{8}$
7. How many moles of $KMnO_4$ are needed to oxidise a mixture of 1 mole each of $FeSO_4$, FeC_2O_4 and $Fe_2(C_2O_4)$ completely in each medium:
   (a) 5 (b) 2 (c) 4 (d) 6
8. The volume of 0.5 M H_2SO_4 required to dissolve 0.5 g of copper (II) carbonate ($CuCO_3$) is:
   (a) 8.09 mL (b) 7.0 mL (c) 10.4 mL (d) 5.09 mL
9. The equivalent weight of the metal, when 1.0 g of metal nitrate gave 0.86 g of metal is
   (a) 48 (b) 28 (c) 38 (d) 36

Multiple Correct Answers Type

10. Which are correct about the reaction?
    $$FeS_2 + O_2 \longrightarrow Fe_2O_3 + SO_2$$
    (a) Eq. mass of FeS_2 is M/11
    (b) Eq. mass of SO_2 = M/5
    (c) 1 mole of FeS_2 requires 7/4 mole of O_2
    (d) S has –2 oxidation state in FeS_2
11. 150 mL $\frac{M}{10}$ $Ba(MnO_4)_2$ in acidic medium can completely oxidises:
    (a) 150 mL of 1 M Fe^{2+} (b) 50 mL of FeC_2O_4
    (c) 75 mL of 1 M $C_2O_4^{2-}$ (d) 25 mL of $K_2Cr_2O_7$ solution
12. A mixture of Cu_2S and CuS on oxidation by $Al(MnO_4)_3$ in acidic medium gives Cu^{2+} and SO_2. If molar masses of Cu_2S, CuS and $Al(MnO_4)_3$ are M_1, M_2 and M_3 respectively, then for this reaction which one are correct?
    (a) Equivalent mass of CuS is $\frac{M_1}{8}$
    (b) Equivalent mass of CuS is $\frac{M_2}{5}$
    (c) Equivalent mass of $Al(MnO_4)_3$ is $\frac{M_3}{5}$
    (d) Equivalent mass of $Al(MnO_4)_3$ is $\frac{M_3}{15}$

13. For the following balanced redox reaction:

$$2MnO_4^- + 8H^+ + Br_2 \longrightarrow 2Mn^{2+} + 2BrO_3^- + 2H_2O$$

If the molecular weight of MnO_4^- : Br_2 and Br_2 be M_1, M_2 respectively, then

(a) Equivalent weight of MnO_4^-

(b) Equivalent weight of Br_2 is $M_2/10$

(c) The *n*-factor ratio of MnO_4^- : Br_2 is 1 : 1

(d) None of these

Matching Column Type

14. Match the following:

Column I		Column II	
a.	$As_2S_3 \rightarrow As^{5+} + SO_4^{2-}$	p.	M/28
b.	$CrI_3 \rightarrow Cr_2^{6+} + I^{5+}$	q.	M/33
c.	$CrI_3 \rightarrow Cr_2^{6+} + I^{7+}$	r.	M/27
d.	$CrI_3 \rightarrow Cr^{6+} + I^{7+}$	s.	M/21

Integer Type

15. 600 mL of HNO_3 and 200 mL of $Ca(OH)_2$ of same molarity are mixed to give a resulting solution having pH = 1. What is the molarity of HNO_3 and $Ca(OH)_2$?

Comprehension Type

Bleaching powder and bleach solution are produced on a large scale and used in several household products. The effectiveness of bleach solution is often measured by iodometry.

16. Bleaching powder contains a salt of an oxoacid as one of its compounds. The anhydride of that oxoacid is:

(a) Cl_2O (b) Cl_2O_7
(c) ClO_2 (d) Cl_2O_6

17. 25 mL of household bleach solution was mixed with 30 mL of 0.50 M KI and 10 mL of 4 N acetic acid. In the titration of the liberated iodine, 48 mL of 0.25 N $Na_2S_2O_3$ was used at the end point. The molarity of the household bleach solution is:

(a) 0.48 M (b) 0.96 M
(c) 0.24 M (d) 0.024 M

Answers Key

Subjective Type

1. (a) 152, 20.42; (b) 63, 54; (c) 232, 52.67; (d) 166, 49; (e) 27.5; (f) 12.4; (g) 4.67; (h) 158, 127; (i) 48

2. (a) 18.97 g (b) 1 N

3. 66%

Single Correct Answer Type

4. (a) **5.** (a) **6.** (b) **7.** (b) **8.** (a)
9. (c)

Multiple Correct Answers Type

10. (a, b, c) **11.** (a, b, c)
12. (a, d) **13.** (a, b)

Matching Column Type

14. (a → p, s), (b → r, s), (c → r), (d → r)

Integer Type

15. (0.8)

Comprehension Type

16. (a) **17.** (c)

CHAPTER 2

Redox Reactions

DPP 2.1

Oxidation Number, Oxidizing and Reducing Agents

Subjective Type

1. One mole of N_2H_4 loses 10 moles electrons to form a new compound Y. Assuming that all the N_2 appears in new compound, what is oxidation state of N in Y?
2. Identify the substance acting as oxidant or reductant reduced if any in the following:

   (i) $AlCl_3 + 3K \longrightarrow Al + 3KCl$

   (ii) $SO_2 + 2H_2S \longrightarrow 3S + H_2O$

   (iii) $BaCl_2 + Na_2SO_4 \longrightarrow BaSO_4 + 2NaCl$

   (iv) $3I_2 + 6NaOH \longrightarrow NaIO_3 + 5NaI + 3H_2O$
3. HNO_3 acts only as oxidant whereas HNO_2 acts as reductant and oxidant both. Explain.
4. Determine the oxidation no. of following elements given in bold letters:

   (a) $\mathbf{Fe}_{0.94}O$ (b) $Na_2[\mathbf{Fe}(CN)_5NO]$

   (c) Dimethyl sulphoxide or $(CH_3)_2\mathbf{S}O$

   (d) $\mathbf{Cr}O_5$ or $\mathbf{Cr}O(O_2)_2$ (e) $Ba_2\mathbf{Xe}O_6$

   (f) $\mathbf{C}_3O_2$ (g) $Ca(\mathbf{Cl}O_2)_2$

   (h) $K[\mathbf{Co}(C_2O_4)_2 \cdot (NH_3)_2]$ (i) $Na_2\mathbf{S}_2$
5. Find the oxidation number of Fe in Fe_3O_4 and in $Fe(III)_4[Fe(II)(CN)_6]_3$.

Single Correct Answer Type

6. Which of the following have been arranged in the decreasing order of oxidation number of sulphur?

   (a) $S_2O_6^{2-} > S_2O_7^{2-} > S_2O_3^{2-} > S_8$

   (b) $H_2SO_4 > SO_2 > H_2S > H_2S_2O_8$

   (c) $SO_2^{2+} > SO_4^{2+} > SO_3^{2-} > HSO_4^-$

   (d) $H_2SO_5 > H_2SO_3 > SCl_2 > H_2S$
7. Oxidation number of Pr in Pr_6O_{11} is

   (a) $\frac{22}{6}$ (b) $\frac{20}{6}$ (c) 3 (d) 4
8. In which case oxidation number of Cr has been affected?

   (a) $2CrO_4^{2-} + 2H^+ \longrightarrow Cr_2O_7^{2-} + H_2O$

   (b) $Cr_2O_7^{2-} + 2OH^- \longrightarrow 2CrO_4^{2-} + H_2O$

   (c) $(NH_4)_2Cr_2O_7 \longrightarrow N_2 + Cr_2O_3 + 4H_2O$

   (d) $CrO_2Cl_2 + 2OH^- \longrightarrow CrO_4^{2-} + 2HCl$
9. Prussian blue has two types of iron with oxidation number as shown: $\overset{III}{Fe}[\overset{II}{Fe}(CN)_6]$. What is the net charge on Prussian blue?

   (a) −1 (b) +1 (c) 0 (d) −2

10. Iodine has +7 oxidation state in

(a) HIO_4
(b) H_3IO_5
(c) H_5IO_6
(d) All of these

11. The oxidation number of phosphorus in $Ba(H_2PO_2)_2$ is

(a) +3
(b) +2
(c) +1
(d) −1

12. In which of the following transformations, oxygen is not the reducing agent?

(a) $Ag_2O \longrightarrow 2Ag + \frac{1}{2}O_2$

(b) $4NH_3 + 3O_2 \longrightarrow 2N_2 + 6H_2O$

(c) $2F_2 + 2H_2O \longrightarrow + 4HF + OH_2$

(d) $AgNO_3 + H_2O_2 \longrightarrow 2Ag + 2HNO_3 + O_2$

13. In the reaction,

$Cu + H_2SO_4 \longrightarrow CuSO_4 + H_2O + SO_2$

(a) H^+ is the oxidation agent
(b) SO_4^{2-} is the oxidising agent
(c) Both (a) and (b) are correct
(d) None of the above is correct

Multiple Correct Answers Type

14. Which of the following can be used as oxidant and reductant both?

(a) HNO_2
(b) SO_2
(c) O_2
(d) CO

15. Which of the following are the examples of nonmetal displacement reactions?

(a) $Cd(s) + 2HCl(aq) \xrightarrow{\Delta} CdCl_2(aq) + H_2(g)$

(b) $CuSO_4(aq) + Zn(s) \xrightarrow{\Delta} Cu(s) + ZnSO_4(aq)$

(c) $TiBr_4(l) + 2Mg(s) \xrightarrow{\Delta} 2MgBr_2(s) + Ti(s)$

(d) $Zn(s) + 2HCl(aq) \xrightarrow{\Delta} ZnCl_2(aq) + H_2(g)$

16. Which of the following reaction form the basis of layer test.

(a) $TiBr_4(l) + 2Mg(s) \xrightarrow{\Delta} 2MgBr_2(s) + Ti(s)$

(b) $F_2 + 2I^{\ominus} \longrightarrow I_2 + 2F^{\ominus}$

(c) $Cl_2(g) + 2Br^-(aq) \longrightarrow 2Cl^-(aq) + Br_2(l)$

(d) $Cl_2(g) + 2I^-(aq) \longrightarrow 2Cl^-(aq) + I_2(s)$

17. Which one are not correct about $CH_2 = CCl_2$?

(a) Both carbon are in +2 oxidation state
(b) Both carbon are in −2 oxidation state
(c) One carbon has +2 and other has −2 oxidation state
(d) The average oxidation number of carbon is zero

18. Select the correct statements:

(a) Oxidation number of oxygen in O_2^+ is $+\frac{1}{2}$

(b) Oxidation number of oxygen in O_2^- is $-\frac{1}{2}$

(c) Oxidation number of Cr in K_3CrO_8 is +5

(d) Average oxidation number of Br in tribromo-octaoxide (Br_3O_8) is $+\frac{18}{3}$

Matching Column Type

19. Match the half-reactions (in Column I) with change in oxidation number (in Column II):

Column I		Column II	
a.	$Cl^- \longrightarrow ClO_4^-$	p.	2
b.	$Cr^{3+} \longrightarrow CrO_5$	q.	8
c.	$H_2O_2 \longrightarrow O_2$	r.	0
d.	$CrO_2^{2+} \longrightarrow CrO_4^{2-}$	s.	3

Integer Type

20. Oxidation state of terminal sulphur atoms in $S_4O_6^{2-}$ (tetrathionate ion) are .....

21. The value of *n* in molecular formula $Be_n Al_2 Si_6 O_{18}$ is .....

Comprehension Type

In the chemical change:

$aN_2H_4 + bBrO_3^- \longrightarrow aN_2 + bBr^- + 5H_2O$, answer the following questions:

22. The element oxidised and reduced in the reaction are respectively:

(a) N_2H_4, BrO_3^-
(b) N, Br
(c) H, Br
(d) BrO_3^-, N_2H_4

23. The number of electrons lost or gained during the redox change are:

(a) 8
(b) 10
(c) 12
(d) 6

24. The values of *a* and *b* in the reaction are respectively:

(a) 3, 2
(b) 2, 3
(c) 4, 6
(d) 6, 4

25. The species acting as oxidant and reductant respectively are:

(a) BrO_3^-, N_2H_4
(d) N_2H_4, BrO_3^-
(c) N_2, BrO_3^-
(d) Br^-, N_2H_4

26. The conjugate pair of oxidant-reductant is:

(a) BrO_3^-, Br^-
(b) $N_2H_4^-, BrO_3^-$
(c) Br^-, N_2
(d) Br^-, BrO_3^-

27. Which reaction is this?

(a) intermolecular redox
(b) auto redox
(c) intramolecular redox
(d) either of these

Answers Key

Subjective Type

1. $a = +3$
2. (i) $AlCl_3$, K, (ii) SO_2, H_2S, (iii) None is oxidant or reductant (iv) I_2 acts as oxidant and reductant both
4. (a) 2.12, (b) 2, (c) 0, (d) +6, (e) +8, (f) $\frac{4}{3}$, (g) +3, (h) +3, (i) −1
5. $\frac{+8}{3}, +\frac{18}{7}$

Single Correct Answer Type

6. (d) **7.** (a) **8.** (c) **9.** (a) **10.** (d)
11. (c) **12.** (b) **13.** (b)

Multiple Correct Answers Type

14. (a, b, c, d) **15.** (a, d) **16.** (c, d)
17. (a, b) **18.** (a, b, c)

Matching Column Type

19. (a → q), (b → s), (c → p), (d → r)

Integer Type

20. (5) **21.** (3)

Comprehension Type

22. (b) **23.** (c) **24.** (a) **25.** (a) **26.** (a)
27. (a)

DPP 2.2

Balancing of the Equation

Subjective Type

1. Find out the value of *n* in:

$$MnO_4^- + 8H^+ + ne \longrightarrow Mn^{2+} + 4H_2O$$

2. Balance the following equations:

(a) $BaCrO_4 + KI + HCl \longrightarrow BaCl_2 + I_2 + KCl + CrCl_3 + H_2O$

(b) $SO_2 + Na_2CrO_4 + H_2SO_4 \longrightarrow Na_2SO_4 + Cr_2(SO_4)_3 + H_2O$

3. Eight mole of chlorine (Cl_2) undergoes a loss and gain of 14 mole of electrons to form two oxidation states of chlorine (Cl). Write down the two half reactions and equation for disproportionate of chlorine, Cl_2.

4. Find the equivalent weight of $KClO_3$ in $3KClO_3 + 3H_2SO_4 \longrightarrow 3KHSO_4 + HClO_4 + 2ClO_2 + H_2O$

Single Correct Answer Type

5. Values of *p*, *q*, *r*, *s* and *t* are in the following redox reaction

$$pBr_2 + qOH^- \longrightarrow rBr^- + sBrO_3^- + tH_2O$$

	p	q	r	s	t
(a)	3	6	1	5	3
(b)	3	6	5	3	1
(c)	3	6	5	1	3
(d)	3	5	1	6	3

6. $Cr_2O_7^{2-} + 2I^- + 14H^+ \longrightarrow I_2 + 2Cr^{3+} + 7H_2O$

Which are not in balanced position?

(a) H^+ and H_2O
(b) $Cr_2O_7^{2-}$ and Cr^{3+}
(c) I^- and I_2
(d) All the above are balanced

7. CuS is dissolved in dil. HNO_3. Balanced equation with correct products is

(a) $CuS + 2H^+ + 3NO_3^- \longrightarrow Cu(NO_3)_2 + H_2S + H_2O + NO_2$

(b) $3CuS + 8H^+ + 8NO_3^- \longrightarrow 3Cu(NO_3)_2 + 3S + 4H_2O + 2NO$

(c) $CuS + 4NO_3^- \longrightarrow Cu(NO_3)_2 + H_2S + H_2O$

(d) None of the above is correct

8. What is the molecular state of sulphur as reactant in:

sulphur + $12OH^- \longrightarrow 4S^2 + 2S_2O_3^{2-} + 3H_2O$?

(a) S_8^{2-}
(b) $2S_4^{2-}$
(c) S_8
(d) S_8^-

9. In balancing the half-reaction

$$CN^- \longrightarrow CNO^- \text{ (skeletal)}$$

the number of electrons that must be added is

(a) 0
(b) 1 on the right
(c) 1 on the left
(d) 2 on the right

10. In the following reaction (unbalanced), equivalent weight of As_2S_3 is related to molecular weight M by

$$As_2S_3 + H^+ + NO_3^- \longrightarrow NO + H_2O + AsO_4^{3-} + SO_4^{2-}$$

(a) $\frac{M}{2}$
(b) $\frac{M}{4}$
(c) $\frac{M}{28}$
(d) $\frac{M}{24}$

11. In the following unbalanced redox reaction,

$$Cu_3P + Cr_2O_7^{2-} \longrightarrow Cu^{2+} + H_3PO_4 + Cr^{3+}$$

Equivalent weight of H_3PO_4 is

(a) $\frac{M}{3}$
(b) $\frac{M}{6}$
(c) $\frac{M}{7}$
(d) $\frac{M}{8}$

Multiple Correct Answers Type

12. Select the correct statements.

Equivalent weight of $KMnO_4$ (molar mass = M) is

(a) $\frac{M}{5}$ in acidic medium

(b) $\frac{M}{3}$ in dilute basic medium

(c) M in strongly alkaline medium

(d) $\frac{M}{2}$ in acidic, basic and neutral media

13. Select the correct statement(s).

(a) Equivalent weight of $Ca(HC_2O_4)_2$ is $\frac{M}{2}$ when it is a reducing agent

(b) Equivalent weight of $Ca(HC_2O_4)_2$ is M when it behaves as an acid

(c) $Ca(HC_2O_4)_2$ can be estimated by MnO_4^-/H^+

(d) $Ca(HC_2O_4)_2$ can be estimated by an acid

14. Consider the following reaction,

$$Br_2 + OH^- \longrightarrow BrO_3^- + Br^- + H_2O \text{ (unbalanced)}$$

Select the correct statement.

(a) Equivalent weight of Br_2 when it is reduced to Br^- is 80

(b) Equivalent weight of Br_2 when it is oxidised to BrO_3^- is 96

(c) Net equivalent weight of Br_2 is 96

(d) It is a disproportionation reaction

15. Which is correct about tailing of Hg?

(a) it is due to Hg_2O (b) it is due to HgO

(c) it is removed by H_2O_2 (d) it is removed by O_3

16. For the reaction:

$$I^- + ClO_3^- + H_2SO_4 \longrightarrow Cl^- + HSO_4^- + I_2$$

The correct statement(s) in the balanced equation is/are:

(a) Stoichiometric coefficient of HSO_4^- is 6.

(b) Iodide is oxidized

(c) Sulphur is reduced

(d) H_2O in one of the products.

Matching Column Type

17. Only one match from each list:

List I		List II		List III	
a.	CH_4	(i)	E. mass = M/8	p.	$C^{2+} \longrightarrow C^{4+}$
b.	CO	(ii)	E. mass = M/2	q.	$C^{-4} \longrightarrow C^{4+}$
c.	$C_2O_4^{2-}$	(iii)	E. mass = M/12	r.	$C^{3+} \longrightarrow C^{4+}$
d.	C_2H_4			s.	$C^{-2} \longrightarrow C^{4+}$

Integer Type

18. How many species will have multiple of '2' in the following equation after balancing? Balanced equation must contain least integral multiple.

$$CrSCN^{2+} + BrO^- + OH^- \longrightarrow Br^- + NO_3^- + CO_3^{2-} + SO_4^{2-} + CrO_4^{2-} + H_2O$$

19. Number of moles of electrons are needed to convert one mole of nitrate ion to hydrazine are .....

Comprehension Type

$K_2Cr_2O_7$ acts as a good oxidizing agent in acidic medium.

$$\underset{\text{Orange}}{Cr_2O_7^{2-}} + 14H^+ + 6e^- \longrightarrow \underset{\text{Green}}{2Cr^{3+}} + 7H_2O$$

In alkaline solution, orange colour of $Cr_2O_7^{2-}$ changes to yellow colour due to formation of CrO_4^{2-} and again yellow colour changes to orange colour on changing the solution to acidic medium.

$$\underset{\text{Orange}}{Cr_2O_7^{2-}} + 2OH^- \longrightarrow \underset{\text{Yellow}}{2CrO_4^{2-}} + H_2O$$

$$\underset{\text{Yellow}}{2CrO_4^{2-}} + 2H^+ \longrightarrow \underset{\text{Orange}}{2Cr_2O_7^{2-}} + H_2O$$

When H_2O_2 is added to an acidified solution of dichromate ion, a complicated reaction occurs. The products obtained depend on the pH and concentration of Cr.

20. What happens when a solution of potassium chromate is treated with an excess of dilute nitric acid?

(a) Cr^{3+} and $Cr_2O_7^{2-}$ are formed

(b) $Cr_2O_7^{2-}$ and H_2O are formed

(c) CrO_4^{2-} is reduced to +3 state of Cr

(d) CrO_4^{2-} is reduced to 0 state of Cr

21. Which of the following statement is wrong when a mixture of NaCl and $K_2Cr_2O_7$ is gently warmed with conc. H_2SO_4?

(a) A deep red vapour is evolved

(b) The vapour when passed through NaOH solution gives a yellow solution of Na_2CrO_4

(c) Chlorine gas is formed

(d) Chromyl chloride is formed

22. The CrO_3 on reaction with HCl and NaOH(aq.) gives respectively:

(a) CrO_2Cl_2, CrO_4^{2-} (b) $Cr(OH)_2$, CrO_4^{2-}

(c) Cl_2, $Cr_2O_7^{2-}$ (d) Cl_2, $Cr(OH)_3$

23. Number of moles of $K_2Cr_2O_7$ reduced by one mole of Sn^{2+} ions in acidic medium is:

(a) $\frac{1}{3}$ (b) 3 (c) $\frac{1}{6}$ (d) 6

Answers Key

Subjective Type

1. 5

2. (a) $2BaCrO_4 + 6KI + 16\ HCl \rightarrow 2CrCl_3 + 3I_2 + 6HCl + 2BaCl_2 + 8H_2O$

(b) $3SO_2 + 2Na_2CrO_4 + 2H_2SO_4 \rightarrow 2Na_2SO_4 + Cr_2(SO_4)_3 + 2H_2O$

4. $M + \frac{M}{2}$

Single Correct Answer Type

5. (c) **6.** (c) **7.** (b) **8.** (c) **9.** (d)

10. (c) **11.** (d)

Multiple Correct Answers Type

12. (a, b, c) **13.** (a, b, c)

14. (a, c, d) **15.** (a, c) **16.** (a, b, d)

Matching Column Type

17. (a → (i) → q), (b → (ii) → p), (c → (ii) → r), (d → (iii) → s)

Integer Type

18. (5) **19.** (7)

Comprehension Type

20. (b) **21.** (c) **22.** (a) **23.** (a)

CHAPTER

3 Atomic Structure

DPP 3.1

Basic Terms, Rutherford's Model, Electromagnetic Wave Theory, Planck's Quantum Theory

Subjective Type

1. If the atomic weight of Zn is 70, and its atomic number is 30, then what will be the atomic weight of Zn^{2+}?
2. Oxygen consists of isotopes O^{16}, O^{17} and O^{18}, and carbon consists of isotopes C^{12} and C^{13}. How many types of CO_2 molecules can be formed? Also report their molecular weights.
3. Yellow light emitted from a sodium lamp has wavelength (λ) of 580 nm. Find the frequency (ν) and wave number ($\bar{\nu}$) of the yellow light.
4. Calculate the number of protons emitted in 10 hours by a 60 W sodium lamp (λ of photon = 5893 Å).
5. When a certain metal was irradiated with light of frequency $4.0 \times 10^{16}\ s^{-1}$, the photoelectrons emitted had three times the kinetic energy as the kinetic energy of photoelectrons emitted when the metal was irradiated with light of frequency $2.0 \times 10^{16}\ s^{-1}$. Calculate the critical frequency (v_0) of the metal.
6. In Milikan's experiment, static electric charge on the oil drops has been obtained by shining X-rays. If the static electric charge on the oil drop is -1.282×10^{-18} C. Calculate the number of electrons present on it.
7. % of α-particles which are sent back in direction of projection of α-particle (in Rutherford's experiment) is 5×10^{-x}. Give value of x.
8. Radius of nucleus of Al is $x \times 10^{-15}$ m. Give value of x in the form of nearest integer as 2.2 should be reported as 2 and 2.8 should be reported as 3. (Mass no. of Al = 27).

Single Correct Answer Type

9. In two elements ${}_{Z_1}A^{M_1}$ and ${}_{Z_2}B^{M_2}$. $M_1 \neq M_2$ and $Z_1 \neq Z_2$ but $M_1 - Z_1 = M_2 - Z_2$. These elements are
   (a) Isotonic
   (b) Isobaric
   (c) Isotopic
   (d) Isoprotonic
10. Moseley's equation for the determination of wavelength of X-rays is (v = frequency of wave, Z = nuclear charge, a and b are constants)
    (a) $\sqrt{\text{v}} = Z - ab$
    (b) $v = a(Z - b)$
    (c) $\sqrt{\text{v}} = a(Z - b)$
    (d) $v = Z - ab$
11. Light of wavelength λ shines on a metal surface with intensity X, and the metal emits Y electrons per second of average energy Z. what will happen to Y and Z if X is doubled?
    (a) Y will be doubled and Z will become half.
    (b) Y will remain same and Z will be doubled.
    (c) Both Y and Z will be doubled
    (d) Y will be doubled but Z will remain same.
12. Number of α-particles scattered by an angle θ in Rutherford's experiment are
    (a) Directly proportional to $K.E^2$
    (b) Directly proportional to z^4
    (c) Inversely proportional to e^4
    (d) Inversely proportional to $K.E^2$
13. The ejection of the photoelectron from the silver metal in the photoelectric effect experiment can be stopped

by applying a voltage of 0.35 V when the radiation 256.7 nm is used. Calculate the work function for silver metal.

(a) 3.21 eV (b) 0.35 eV

(c) 4.48 eV (d) 4.83 eV

14. The approximate radius of a H-atom is 0.05 nm, and that of proton is 1.5×10^{-15} m. Assuming both the hydrogen atom and the proton to be spherical, calculate fraction of the space in an atom of hydrogen that is occupied by the nucleus.

(a) 2.7×10^{-14} (b) 2.7×10^{-10}

(c) 5×10^{-14} (d) 2×10^{-16}

15. One quantum is absorbed per gaseous molecule of Br_2 for converting into Br atoms. If light absorbed has wavelength 5000 Å, calculate energy required in kJ/mol.

(a) 240 (b) 250

(c) 257 (d) 210

Multiple Correct Answers Type

16. In Rutherford's gold leaf experiment, the scattering of α-particles takes place. In this process:

(a) coulombic force is involved

(b) nuclear force is involved

(c) path of α-particle is parabolic

(d) path of α-particle is hyperbolic

17. When high speed electron strikes a metal surface, which of the following are possible?

(a) The entire energy of the electron may be converted into X-ray photon

(b) Fraction of energy of electron may be converted into X-ray photon

(c) The entire energy of electron may be converted into heat

(d) The electron may undergo elastic collision with metal surface

18. Which of the following properties are possessed by cathode ray?

(a) Dual nature

(b) Travel with speed of light

(c) Have negative charge

(d) Possess magnetic effect

19. Which of the following properties is/are proportional to the energy of the electromagnetic radiation?

(a) Frequency (b) Wave number

(c) Wavelength (d) Number of photons

20. Energy equivalent of 10.00 cm^{-1} is

(a) 2×10^{-22} J per photon

(b) 2.9×10^{-2} kcal mol^{-1} photon

(c) 1.2×10^{-1} kJ mol^{-1} photon

(d) 2×10^{-15} ergs per photon

Matching Column Type

21. Match the following:

	Column I		Column II
a.	Plum-Pudding model	p.	1.6022×10^{-19}C
b.	Planetary model of atom	q.	Thomson's model
c.	Atoms are indivisible	r.	Rutherford's model
d.	Charge on electron	s.	±1/2
e.	The spin of electron is	t.	Dalton theory

Integer Type

22. A radiation of wavelength λ illuminates a metal and ejects photoelectrons of maximum kinetic energy of 1 eV. Another radiation of wave length $\frac{\lambda}{3}$, ejects photoelectrons of maximum kinetic energy of 4 eV. What will be the work function of metal in terms of $x \times 10^{-1}$ eV, where x is

Comprehension Type

The emission of electrons from a metal surface when exposed to light radiation of appropriate wavelength is called photoelectric effect. The emitted electrons are called photo-electrons. Work function of threshold energy may be defined as the minimum amount of energy required to eject electrons from a metal surface. According to Einstein,

Maximum kinetic energy of ejected electron

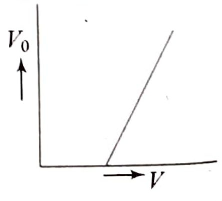
= Absorbed energy – Work function

$$\frac{1}{2}mv^2_{\max} = h(\nu) - h(\nu_0) = hc\left[\frac{1}{\lambda} - \frac{1}{\lambda_0}\right]$$

where ν_0 and λ_0 are threshold frequency and threshold wavelength, respectively.

Stopping potential: It is the minimum potential at which the photoelectric current becomes zero. If V_0 is the stopping potential $eV_0 = h(\nu - \nu_0)$.

23. In the photoelectric effect, the slope of straight line graph between stopping potential (V_0) and frequency of incident light (ν) gives



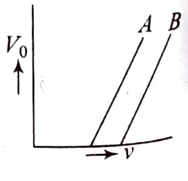
(a) charge on electron

(b) work function of emitter

(c) Planck's constant

(d) ratio of Planck's constant to charge on electron

24. The stopping potential as a function of frequency is plotted for two photoelectric surfaces A and B. The graph show that the work function of A is



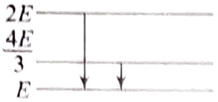
(a) Greater than that of B

(b) Smaller than that of B

(c) Same as that of B

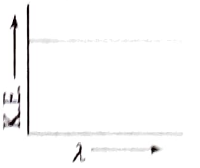
(d) Such that no comparison can be done from given graphs

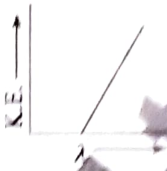
25. The following figure indicates the energy levels of a certain atom. When the system moves from 2E level to E level, a photon of wavelength λ is emitted. The wavelength of the photon produced during the transition from level 4E/3 to level E is

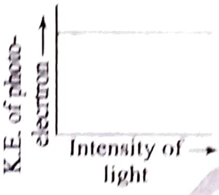


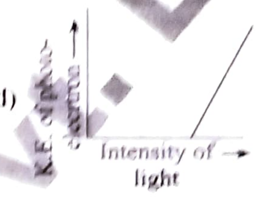
(a) $\frac{\lambda}{3}$ (b) $\frac{3\lambda}{4}$ (c) $\frac{4\lambda}{3}$ (d) 3λ

26. Which graph is correct?

(a)


(b)


(c)


(d)


Answers Key

Subjective Type

1. 70
2. Six molecules with C^{13} isotopes can be found
3. $1.72 \times 10^6\ m^{-1}$
4. 6.41×10^{24}
5. $1 \times 10^{16}\ s^{-1}$
6. 8
7. 3
8. 4

Single Correct Answer Type

9. (a) **10.** (c) **11.** (d) **12.** (d) **13.** (c)
14. (a) **15.** (a)

Multiple Correct Answers Type

16. (a, d) **17.** (a, b, c) **18.** (a, b, c, d)
19. (a, b, d) **20.** (a, b, c, d)

Matching Column Type

21. (a → q), (b → r), (c → t), (d → p), (e → s)

Integer Type

22. (5)

Comprehension Type

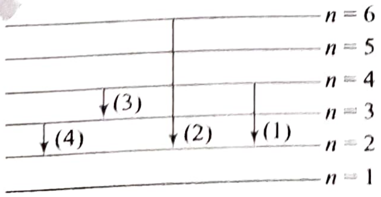
23. (d) **24.** (b) **25.** (d) **26.** (c)

DPP 3.2

Bohr Theory and Hydrogen Spectrum

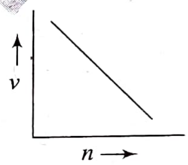
Subjective Type

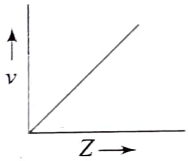
1. Calculate the wavelength of the first line in the Balmer series of hydrogen spectrum.
2. Find the wavelength of radiation required to excite an electron in the ground level of Li^{2+} ($z = 3$) to the third energy level.
3. Find the energy released (in joules) when a doubly ionized helium ion (He^{2+}) takes up two electrons to form a helium atom in the ground state. The first ionization energy of a helium atom is 3.4×10^{-19} J.
4. The circumference of the first Bohr orbit in H atom is 3.322×10^{-10} m. What is the velocity of the electron of this orbit?
5. A single electron ion has nuclear charge $+Ze$ where Z is atomic number and e is electronic charge. It requires 16.52 eV to excite the electron from the second Bohr orbit to third Bohr orbit. Find
   (a) The atomic number of element.
   (b) The energy required for transition of electron from first to third orbit.
   (c) Wavelength required to remove electron from first Bohr orbit to infinity.
   (d) The kinetic energy of electron in first Bohr orbit.
6. He^+ ions are in an excited state from where maximum 6 types of photons can be emitted. If E is the separation energy of He^+ from this excited state, than how many times of energy E is required to ionise hydrogen atom.
7. Separation energy of a hydrogen like ion from its third excited state is 2.25 times the separation energy of hydrogen atom from its first excited state. Find out the atomic number of hydrogen like ion.
8. For a beam of radiation coming out from a sample of He^+ ions the following energy level diagram was observed (The beam only had photons corresponding to these transitions). If the above beam of radiations is used to excite a sample of H-atoms in ground state, then find the wavelengths of the photons subsequently emitted by the H-atoms.

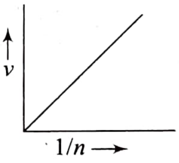


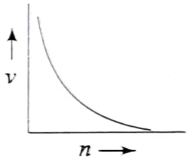
Single Correct Answer Type

9. What is the difference in the wavelengths of 4th and 5th lines of Balmer series in the spectrum of hydrogen atom?
   (a) 131 Å (b) 520 Å
   (c) 390 Å (d) 262 Å
10. Two electrons are revolving around a nucleus at distances 'r' and '$4r$'. The ratio of their periods is:
    (a) 1 : 4 (b) 4 : 1
    (c) 8 : 1 (d) 1 : 8
11. Which of the following is not correct for the velocity of electron?

(a)


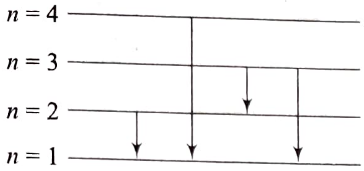
(b)


(c)


(d)


12. The radii of two of the first four Bohr orbits of the hydrogen atom are in the ratio 1 : 4. The energy difference between them may be
    (a) Either 12.09 eV or 3.4 eV
    (b) Either 2.55 eV or 10.2 eV
    (c) Either 13.6 eV or 3.4 eV
    (d) Either 3.4 eV or 0.85 eV
13. Which is the correct relationship:
    (a) E_1 of H = 1/2 E_2 of He^+ = 1/3 E_3 of Li^{2+} = 1/4 E_4 of Be^{3+}
    (b) $E_1(H) = E_2(He^+) = E_3(Li^{2+}) = E_4(Be^{3+})$
    (c) $E_1(H) = 2E_2(He^+) = 3E_3(Li^{2+}) = 4E_4(Be^{3+})$
    (d) No relation
14. In a certain electronic transition in the hydrogen atoms from an initial state (1) to a final state (2), the difference in the orbital radius ($r_1 - r_2$) is 24 times the first Bohr radius. Identify the transition.
    (a) 5 → 1 (b) 25 → 1
    (c) 8 → 3 (d) 6 → 5

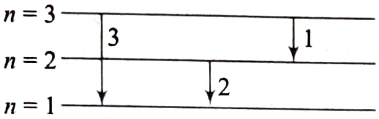
15. Suppose that a hypothetical atom gives a red, given a red, green, blue and violet line spectrum. Which jump according to figure would give off the red spectral line?



(a) $3 \rightarrow 1$ (b) $2 \rightarrow 1$ (c) $4 \rightarrow 1$ (d) $3 \rightarrow 2$

Multiple Correct Answers Type

16.



For above transitions in hydrogen like atoms, select the correct relation(s).

(a) $v_3 = v_1 + v_2$ (b) $v_3 = \frac{v_1 v_2}{v_1 + v_2}$

(c) $\lambda_3 = \lambda_1 + \lambda_2$ (d) $\lambda_3 = \frac{\lambda_1 \lambda_2}{\lambda_1 + \lambda_2}$

17. If the electron of the hydrogen atom is replaced by another particle of same charge but of the double mass, then:
(a) radii of different shells will increase
(b) energy gap between two levels will become double
(c) ionization energy of the atom will be double
(d) speed of new particle in a shell will be lesser than the speed of electron in the same shell

18. Let r, υ and E are the radius of the orbit, speed of the electron and the total energy of the electron respectively. Which of the following quantities are proportional to the quantum number 'n'?

(a) rE (b) υE (c) $\frac{\upsilon}{E}$ (d) $\frac{r}{E}$

19. Select the correct statements for hydrogen like atoms or ions.
(a) Radius of an orbit is inversely proportional to Z
(b) Radius of an orbit is directly proportional to Z^2
(c) Energy of the electron in an orbit is inversely proportional to Z
(d) Energy of the electron in an orbit is directly proportional to Z^2

20. An electron in hydrogen atom makes a transition from $n = n_1$ to $n = n_2$. The time period of the electron in the initial state is eight times that in the final state. The possible values of n_1 and n_2 are:

(a) $n_1 = 4, n_2 = 2$ (b) $n_1 = 8, n_2 = 2$
(c) $n_1 = 8, n_2 = 1$ (d) $n_1 = 6, n_2 = 3$

21. Identify the correct statement(s):
(a) Energy of the electron in 4th orbit of H-atom is more than that of the electron present in 4th orbit of He$^+$ ion
(b) Energy of a quantum is inversely proportional to frequency (v)
(c) Energy of a quantum is inversely proportional to wavelength (λ)
(d) Radius of 1st orbit of He$^+$ ion is 0.529 Å

22. A hydrogen-like atom has ground state binding energy 122.4 eV. Then:
(a) its atomic number is 3
(b) a photon of 90 eV can excite it to a higher state
(c) a 80 eV photon cannot excite it to a higher state
(d) None

Matching Column Type

23. Match the following:

	Column I		Column II
a.	$n_1 \rightarrow n_\infty$ in H atoms	p.	Visible radiations
b.	$n_4 \rightarrow n_2$ in H atoms	q.	Energy numerically equal to Rydberg energy
c.	$n_\infty \rightarrow n_1$ in He$^\oplus$ ion	r.	Energy numerically equal to ionization energy
d.	$n_4 \rightarrow n_2$ in H atoms	s.	Ultraviolet radiations

Integer Type

24. A single electron system has ionization energy 11180 kJ mol^{-1}. The number of protons in the nucleus of the system will be _______ .

25. Number of visible lines when an electron returns from 5th orbit to ground state in H-spectrum is ______ .

26. Which state of the triply ionized Beryllium (Be^{3+}) has the same orbit radius as that of the ground state of hydrogen atom?

Comprehension Type

Suppose Bohr theory is applicable to a negatively charged particle of mass $2m_e$ and charge $2e$ removing around the nucleus of positive charge Ze. Let r_1, v_1 and E_1 be the radius of the orbit speed of the particle in the orbit and energy of the particle in the orbit respectively. The values for the electron revolving in the corresponding orbit are r, v and E respectively.

27. Which of the following expression regarding the ratio of radii is correct?

(a) $\frac{r_1}{r} = 2$ (b) $r_1/r = \frac{1}{2}$

(c) $\frac{r_1}{r} = 4$ (d) $\frac{r_1}{r} = \frac{1}{4}$

28. Which of the following expression regarding the ratio of speeds is correct?

(a) $\frac{v_1}{v} = 2$ (b) $\frac{v_1}{v} = \frac{1}{2}$

(c) $\frac{v_1}{v} = 4$ (d) $\frac{v_1}{v} = \frac{1}{4}$

29. Which of the following expression regarding the ratio of energies is correct?

(a) $\frac{E_1}{E} = 4$ (b) $\frac{E_1}{E} = \frac{1}{4}$

(c) $\frac{E_1}{E} = 8$ (d) $\frac{E_1}{E} = \frac{1}{8}$

Answers Key

Subjective Type

1. 656.5 nm **2.** 113.9 Å
3. 9.02×10^{-18} J **4.** 2.19×10^{6} m s^{-1}
5. (a) 3 (b) 108.81 eV (c) 1.013×10^{-8} m
(d) 122.4 eV
6. $E_H/E_{He^+} = 4$
7. 3 **8.** 6565 Å, 1216 Å, 1026 Å

Single Correct Answer Type

9. (a) **10.** (d) **11.** (a) **12.** (b) **13.** (b)
14. (a) **15.** (d)

Multiple Correct Answers Type

16. (a, d) **17.** (c, d) **18.** (b, c) **19.** (a, d) **20.** (a, d)
21. (a,c) **22.** (a, c)

Matching Column Type

23. (a → q, r, s)

Integer Type

24. (3) **25.** (3) **26.** (2)

Comprehension Type

27. (d) **28.** (a) **29.** (c)

DPP 3.3

Heisenberg's Uncertainty Principle and de Broglie Equation

Subjective Type

1. What is the ratio of the velocities of CH_4 and O_2 molecules so that they are associated with de Broglie waves of equal wavelength?
2. A golf ball has a mass of 40 g and a speed of 45 m s^{-1}. If the speed can be measured with an accuracy of 2%, calculate the uncertainty in the position.
3. If the uncertainty in the position of a moving electron is equal to its de Broglie wavelength, then its velocity will be completely uncertain. Explain.
4. An electron, practically at rest, is initially accelerated through a potential difference of 100 volts. It then has a de Broglie wavelength = λ_1 Å. It then get retarded through 19 volts and then has a wavelength λ_2 Å. A further retardation through 32 volts changes the wavelength to λ_3 Å. What is $\frac{\lambda_3 - \lambda_2}{\lambda_1}$?
5. A photon of 19.6 eV energy strikes a H-atom (in its ground state). Find de Broglie wavelength of electron ejected from H-atom (in Å).
6. A moving electron has kinetic energy equal to 5×10^{-25} J. Derive its de Broglie's wavelength.

Single Correct Answer Type

7. Two particles of masses 'm' and '$2m$' have equal kinetic energies. Their de Broglie wavelengths are in the ratio of:
   (a) 1 : 1 (b) 1 : 2 (c) 1 : $\sqrt{2}$ (d) $\sqrt{2}$: 1
8. The de Broglie wavelength of a neutron at 927°C is λ. What will be its wavelength at 27°C?
   (a) $\lambda/2$ (b) λ (c) 2λ (d) 4λ
9. An electron with velocity v is found to have a certain value of de Broglie wavelength. The velocity that the neutron should possess to have the same de Broglie wavelength is
   (a) v (b) $v/1840$ (c) $1840v$ (d) $1840/v$
10. The uncertainty in position of an electron is equal to its de Broglie wavelength. The minimum percentage error in its measurement of velocity under this circumstance will be approximately
    (a) 4 (b) 8 (c) 22 (d) 18
11. An electron is continuously accelerated in vacuum tube by applying potential difference. If its de Broglie wavelength is decreased by 1%, the change in the kinetic energy of the electron is nearly
    (a) Decreased by 1.0% (b) Increased by 2.0%
    (c) Increased by 1.0% (d) Decreased by 2.0%
12. If uncertainty in the measurement of position and momentum of an electron are equal then uncertainty in the measurement of its velocity is approximately:
    (a) 8×10^{12} m s^{-1} (b) 6×10^{12} m s^{-1}
    (c) 4×10^{12} m s^{-1} (d) 2×10^{12} m s^{-1}
13. If wavelength is equal to the distance travelled by the electron in one second, then
    (a) $\lambda = h/p$ (b) $\lambda = h/m$
    (c) $\lambda = \sqrt{h/p}$ (d) $\lambda = \sqrt{h/m}$
14. In H-atom, if 'x' is the radius of the first Bohr orbit, de Broglie wavelength of an electron in 3rd orbit is:
    (a) $3\pi x$ (b) $6\pi x$ (c) $\frac{9x}{2}$ (d) $\frac{x}{2}$
15. Photon having energy equivalent to the binding energy of 4th state of He^+ atom is used to eject an electron from the metal surface of work function 1.4 eV. If electrons are further accelerated through the potential difference of 4V, then the minimum value of de Broglie wavelength associated with the electron is:
    (a) 1.1 Å (b) 5 Å (c) 9.15 Å (d) 11 Å

Multiple Correct Answers Type

16. In which of the following conditions the de Broglie wavelength of particle A will be less than that of particle B ($m_A > m_B$)?
    (a) Linear momentum of these particles are same
    (b) Move with same speed
    (c) Move with same kinetic energy
    (d) Have fallen through same height
17. Heisenberg uncertainty principle is not valid for
    (a) Moving electrons (b) Motor car
    (c) Stationary particles (d) All of the above
18. Which of the following sets of physical phenomena are shown by dual nature of radiation?
    (a) Interference and photoelectric effect
    (b) Diffraction and photoelectric effect
    (c) Interference and diffraction
    (d) Scintillation and interference

19. Select the correct statements if $\hbar = \frac{h}{2}$ and $\hbar = \frac{h}{2\pi}$:

(a) $\Delta p . \Delta x = \frac{h}{2\pi}$ (b) $\Delta p . \Delta x = \frac{\hbar}{2}$

(c) $\Delta u_y . \Delta x = \frac{\hbar}{2\pi m}$ (d) $\Delta u_x . \Delta x = \frac{\hbar}{2\pi m}$

20. The de Broglie equation treats an electron to be

(a) a particle (b) a wave

(c) a ray (d) a beam of light

21. The qualitative order of de broglie wavelength for electron, proton and a particle is $\lambda_e > \lambda_p > \lambda_\alpha$ if

(a) kinetic energy is same for all particles

(b) the accelerating potential difference 'V' is same for all the particles (from rest)

(c) velocities are same for all particles

(d) None of the above

Matching Column Type

22. Match the Column I with Column II

	Column I		Column II
a.	Electrons cannot exist in the nucleus	p.	de Broglie wave
b.	Microscopic particles in motion are associated with	q.	Electromagnetic wave
c.	No medium is required for propagation	r.	Uncertainty principle
d.	Concept of orbit was replaced by orbital	s.	Transverse wave

Integer Type

23. The uncertainty in the position of an electron is equal to its de Broglie wavelength. The minimum percent error in its measurement of velocity under this circumstance will be approximately.

(a) 4 (b) 8

(c) 18 (d) 22

24. The number de Broglie waves made by a Bohr electron in an orbit of maximum magnetic quantum number 3 is ________.

Comprehension Type

It is impossible to determine simultaneously the position of velocity of small microscopic particle such as electron, proton, or neutron with accuracy. This is called Heisenberg's uncertainty principle. Mathematically, it is represented as $\Delta x . \Delta p \geq \frac{h}{4\pi}$. Δx is uncertainty in position. Δp is uncertainty in momentum.

25. If uncertainty in the measurement of position and momentum of an electron are equal, then uncertainty in the measurement of its velocity is approximately

(a) 8×10^{12} m s^{-1} (b) 6×10^{12} m s^{-1}

(c) 4×10^{12} m s^{-1} (d) 2×10^{12} m s^{-1}

26. If a 1.00 g body is travelling along X-axis at 100 cm s^{-1} with an uncertainty in velocity as 2 cm^{-1}. The uncertainty in its position is

(a) 5.28×10^{-30} m (b) 2.64×10^{-30} m

(c) 1.30×10^{-30} m (d) 0.66×10^{-30} m

Answers Key

Subjective Type

1. 2 : 1
2. 1.46×10^{-33} m
4. $\frac{20}{63}$
5. 7
6. 6.94×10^{-7} m

Single Correct Answer Type

7. (d) **8.** (c) **9.** (b) **10.** (b) **11.** (b)
12. (a) **13.** (d) **14.** (b) **15.** (b)

Multiple Correct Answers Type

16. (b, d) **17.** (b, c) **18.** (a, b) **19.** (a, b, d)
20. (a, b) **21.** (a, b, c)

Matching Column Type

22. (a → r), (b → p), (c → q, s), (d → r)

Integer Type

23. (8) **24.** (4)

Comprehension Type

25. (a) **26.** (b)

DPP 3.4

Quantum Numbers, Shape of Orbitals, Electronic Configuration

Subjective Type

1. The wave function of 3s electron is given by

$$\psi_{3s} = \frac{1}{81\sqrt{3\pi}}\left(\frac{1}{a_0}\right)^{3/2}\left[27 - 18\left(\frac{r}{a_0}\right) + 2\left(\frac{r}{a_0}\right)^3\right]e^{-r/3a_0}$$

It has a node at $r = r_0$. Find the relation between r_0 and a_0.

2. Magnetic moment of X^{3+} ion of 3d series is $\sqrt{35}$ B.M. What is atomic number of X^{3+}?

3. A neutral atom has 2K electrons, 8L electrons and 6M electrons. Predict from this:
(a) its atomic number
(b) total number of *s*-electrons
(c) total number of *p*-electrons
(d) total number of *d*-electrons

4. How many elements would be in the third period of the periodic table if the spin quantum number m_s could have the value $-\frac{1}{2}$, 0 and $+\frac{1}{2}$?

5. Calculate the orbital angular momentum of the following orbitals:
(a) 3*p* (b) 3*d* (c) 3*s*

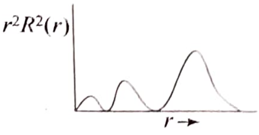
6. Electron of Be^{3+} ion is present in an orbital which has 2 angular nodes and 2 radial nodes. Give sum of $(n + l)$ for orbital in which electron is present.

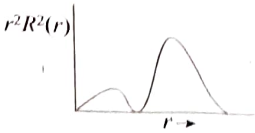
(Given: In this question *n* is principal quantum number and *l* is azimuthal quantum number).

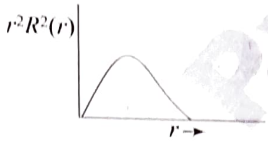
Single Correct Answer Type

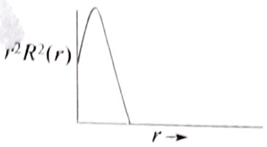
7. The number of waves made by a Bohr electron in an orbit of maximum magnetic quantum number +2 is:
(a) 3 (b) 4 (c) 2 (d) 1

8. Which of the following radial distribution graphs corresponds to $l = 2$ for H atom for the least value of *n* for which $l = 2$ is allowed?

(a)


(b)


(c)


(d)


9. Which of the following set of quantum numbers is an impossible arrangement?
(a) $n = 3, m = 2, s = +1/2$ (b) $n = 4, m = 3, s = +1/2$
(c) $n = 5, m = 2, s = -1/2$ (d) $n = 3, m = -3, s = -1/2$

10. For which of the following electron distributions in ground state, the Pauli's exclusion principle is violated?

(a) 2*s* [↑↓] 2*p* [↑][↑][ ] (b) 2*s* [↑] 2*p* [↑][↑][↑]

(c) 2*s* [↑↑] 2*p* [↑↓][↑][ ] (d) 2*s* [↑↓] 2*p* [↑][↑][↑]

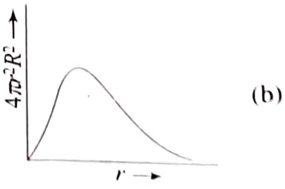
11. The two electrons have the following sets of quantum numbers:

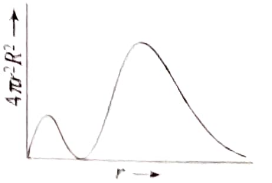
X: 3, 2, –2, +1/2
Y: 3, 0, 0, +1/2

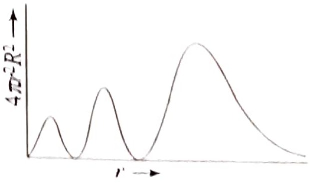
What is true for the following?
(a) *X* and *Y* have same energy
(b) *X* and *Y* have unequal energy
(c) *X* and *Y* represent same electron
(d) None of the statement is correct

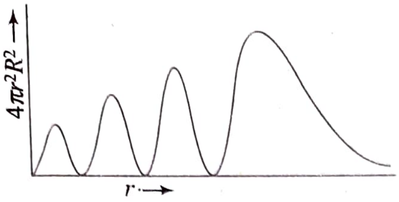
12. How many electrons in an atom with atomic number 105 can have $(n + l) = 8$?
(a) 30 (b) 17
(c) 15 (d) Unpredictable

13. Select the correct plot of radial probability function ($4\pi r^2 R^2$) for 2*s*-orbital.

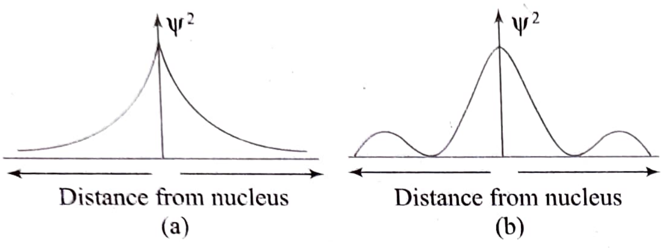
(a)


(b)


(c)


(d)


14. In the following two figures, (ψ^2) is plotted against (r) the distance from nucleus:



(a) Both (A) and (B) are for 1s
(b) Both (A) and (B) are for 2s
(c) (A) is for 1s and (B) is for 2s
(d) (A) is for 2s and (B) is for 1s

15. In case of $d_{x^2-y^2}$ orbital

(a) Probability of finding the electron along x-axis is zero.
(b) Probability of finding the electron along y-axis is zero.
(c) Probability of finding the electron is maximum along x and y-axis.
(d) Probability of finding the electron is zero in x-y plane

Multiple Correct Answers Type

16. Select the correct statements among the following:

(a) An orbital can be defined by four quantum numbers
(b) Absorption spectra are used to identify elements in the outer part of stars
(c) Spectral degeneracy in magnetic field is observed only in single electron species
(d) In black body radiation, the intensity of radiation is directly proportional to T^4

17. The probability of finding the electron in p_x orbital is

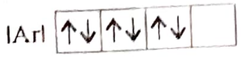
(a) Maximum on two opposite sides of the nucleus along X-axis.
(b) Zero at the nucleus
(c) They produce heating effect
(d) They can affect photographic plate

18. Which of the following statements are incorrect?

(a) There are five unpaired electrons in (n – 1)d suborbital in Fe^{3+}
(b) Fe^{3+}, Mn^+ and Cr all having 24 electrons will have same value of magnetic moment
(c) Copper (I) chloride is coloured salt
(d) Every coloured ion is paramagnetic

19. If Aufbau rule and Hund's rule are not considered, which of the following statements are correct?

(a) Fe^{2+} will have configuration as



(b) Cu^{2+} is colourless ion
(c) Magnetic moment of the Mn is $\sqrt{3}$ BM
(d) K^+ is of d-block

20. Which of the following sets of quantum number are correct?

(a) $n = 3, l = 2, m = +1, s = +\frac{1}{2}$
(b) $n = 3, l = 3, m = +3, s = +\frac{1}{2}$
(c) $n = 4, l = 0, m = 0, s = -\frac{1}{2}$
(d) $n = 5, l = 2, m = +4, s = -\frac{1}{2}$

21. Which of the following statements is/are correct for an electron of quantum numbers $n = 4$ and $m = 2$?

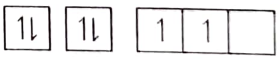
(a) The value of l may be 2
(b) The value of l may be 3
(c) The value of s may be +1/2
(d) The value of l may be 0, 1, 2, 3

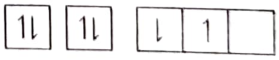
Matching Column Type

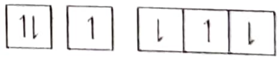
22. Match the following:

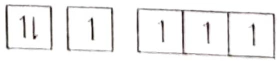
	Column I		Column II (Spin)
a.	$1s^2$	p.	Zero
b.	$1s^2\ 2s^2\ 2p^6$	q.	Zero
c.	$1s^2\ 2s^2\ 2p^5$	r.	±1/2
d.	$2s^2\ 2s^2\ 2p^3$	s.	±3/2
e.	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^2$	t.	±5/2

23. **Column I** **Column II**

(A)


(B)


(C)


(D)


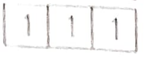
(P) Singlet C in ground state
(Q) Triplet C in ground state
(R) Excited state C having maximum exchange energy
(S) Singlet C in excited state

Integer Type

24. How many of the following ions have the same magnetic moments?

Fe^{2+} Mn^{2+} Cr^{2+} Ni^{2+}

(a) 1 (b) 2 (c) 3 (d) 4

25. Spin multiplicity of p-subshell with configuration

is ______.

26. When 4*f* level is completely filled with electrons, the next electron will enter into a subshell whose $(n + l)$ is equal to ______ .

Comprehension Type

Three quantum numbers viz. principal quantum number (n), azimuthal quantum number (l) and magnetic quantum number (m) are used to designate atomic orbitals and these are derived from Schrodinger wave equation. The another quantum number called spin quantum number is also used to specify an electron in atom but it is not derived from Schrodinger wave equation.

The spin angular momentum is constant and cannot change.

$$\text{Spin angular momentum} = \sqrt{s(s+1)}\frac{h}{2\pi} = \frac{\sqrt{3}}{4}\frac{h}{\pi}$$

It is a vector quantity and it can have only two orientations relative to the selected axis. The orientations are distinguished by the spin quantum number m_s.

$m_s = +\frac{1}{2}$ for clockwise spin (spin up ↑)

$m_s = -\frac{1}{2}$ for anticlockwise spin (spin down ↓)

Answer the following questions:

27. The components of spin angular momentum vector around the chosen axis are limited to:

(a) $\frac{h}{\pi}$ (b) $\pm\frac{1}{2}\frac{h}{2\pi}$ (c) $\frac{\sqrt{3}}{4\pi}h$ (d) $\frac{\sqrt{2}h}{\pi}$

28. What will be the total spin of Fe^{3+} ion?

(a) $5 \times \frac{1}{2}$ (b) $4 \times \frac{1}{2}$ (c) $3 \times \frac{1}{2}$ (d) 1

29. Magnetic quantum number specifies:

(a) size of orbitals
(b) shape of orbitals
(c) orientations of orbitals in space
(d) nuclear stability

30. The energy of an electron in an atomic orbital of a multi electron atom depends on:

(a) the principal quantum number only
(b) the principal and azimuthal quantum numbers only
(c) the principal, azimuthal and magnetic quantum numbers only
(d) the principal, azimuthal magnetic and spin quantum numbers

Answers Key

Subjective Type

1. $r_0 = 3.9a_0$
2. 26
3. (a) 16 (b) 6 (c) 10 (d) 0
4. 27
5. (a) $\sqrt{2}\,\hbar$ (b) $\sqrt{6}\,\hbar$ (c) 0
6. 7

Single Correct Answer Type

7. (a) **8.** (c) **9.** (d) **10.** (c) **11.** (b)
12. (b) **13.** (b) **14.** (c) **15.** (c)

Multiple Correct Answers Type

16. (b, c, d) **17.** (a, b, d) **18.** (b, c)
19. (a, c) **20.** (a, c) **21.** (a, b, c,)

Matching Column Type

22. (a → p), (b → q), (c → r), (d → s), (e → t)
23. (A → Q), (B → P), (C → S), (D → R)

Integer Type

24. (b) **25.** (4) **26.** (7)

Comprehension Type

27. (b) **28.** (a) **29.** (c) **30.** (b)

CHAPTER 4

States of Matter

DPP 4.1

Gas Laws (Boyle's Law, Charles' Law, Gay-Lussac's Law, Avogadro's Law)

Subjective Type

1. A balloon blown up with 1 mole of gas has a volume of 480 mL at 5°C. The balloon is filled to (7/8)th of its maximum capacity. Suggest,

(a) Will the balloon burst at 30°C?

(b) The minimum temperature at which it will burst.

2. A car tyre has a volume of 10 litres when inflated. The tyre is inflated to a pressure of 3 atm at 17°C with air. Due to driving the temperature of tyre increases to 47°C.

(a) What would be the pressure at this temperature?

(b) How many litre of air measured at 47°C and pressure of 1 atm should be let out to restore the tyre to 3 atm at 47°C?

3. A gas filled freely collapsible balloon is pushed from the surface level of lake to a depth of 100 meter. Calculate what per cent of its original volume, the balloon finally has. Assume ideal gas nature.

4. An iron cylinder contains helium at a pressure of 250 kPa at 300 K. The cylinder can withstand a pressure of 1×10^6 Pa. The room in which cylinder is placed catches fire. Predict whether the cylinder will blow up before it melts or not, melting point of cylinder = 1800 K

Single Correct Answer Type

5.

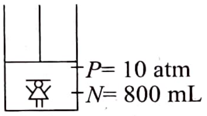


Fig I

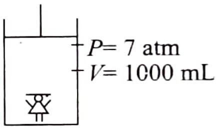


Fig II

In the above figures a doll is entrapped within a piston and cylinder containing gas. Initial and final conditions are shown in Figure-I and Figure-II respectively. The volume of doll is

(a) 1000 mL

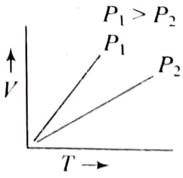
(b) $\frac{15000}{17}$ mL

(c) $\frac{1000}{3}$ mL

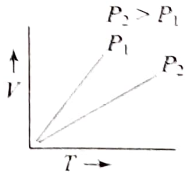
(d) $\frac{1000}{15}$ mL

6. Which of the following graph is/are correct as per Charles law?

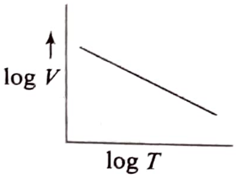
(a)



(b)



(c)



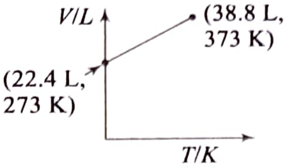
(d) Both (b) and (c) are correct

7. An open vessel contains 200 mg of air at 17°C. What weight percent of air would be expelled if the vessel is heated to 117°C?
   (a) 25.37 (b) 30.37 (c) 25.17 (d) 30.17

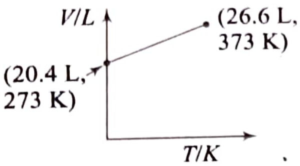
8. A manometer is connected to a gas containing bulb. The open arm reads 43.7 cm whereas the arm connected to the bulb reads 15.6 cm. If the barometric pressure is 743 mm mercury, what is the pressure of gas in bar?
   (a) 13.65 (b) 1.365 (c) 0.1365 (d) 136.5

9. Which of the following volume (V) – temperature (T) plots represents the behaviour of one mole of an ideal gas at one atmospheric pressure?

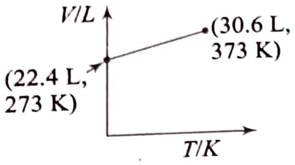
(a)



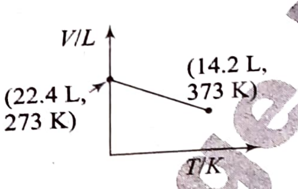
(b)



(c)



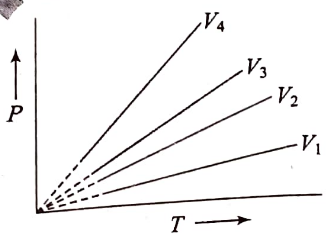
(d)



10. The ideal gas equation for 1 mol of ideal gas is

$$PV = nRT$$

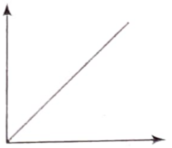
The graph between P and T at constant volume, i.e., isochors are plotted as under:



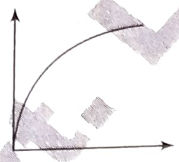
Which of the following order of volume is correct?
(a) $V_4 = V_3 > V_2 > V_1$ (b) $V_1 > V_2 > V_3 > V_4$
(c) $V_1 = V_2 = V_3 = V_4$ (d) $V_2 > V_1 > V_3 > V_4$

11. Which of the following graph represents V vs $\frac{1}{P^2}$ for ideal gas at constant T and n?

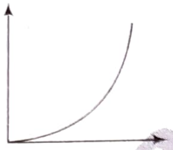
(a)



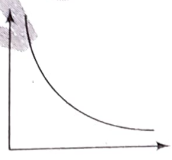
(b)



(c)



(d)



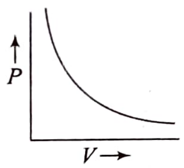
Multiple Correct Answers Type

12. For a fixed mass of a gas at constant pressure, which of the following statements is/are not correct?
    (a) Plot of volume versus Celsius temperature is linear with intercept zero.
    (b) Plot of volume versus Kelvin temperature is linear with a non-zero intercept.
    (c) Plot of V/T versus T is linear with a positive slope
    (d) Plot of V/T versus T is linear with a zero slope

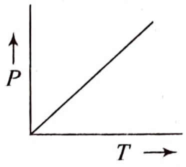
13. Boyle's law cannot be expressed as
    (a) $(dP/dV)_T = K/V$ (b) $(dP/dV)_T = -K/V^2$
    (c) $(dP/dV)_T = -K/V$ (d) $V \propto 1/P$

14. Which of the following plots is/are correct?

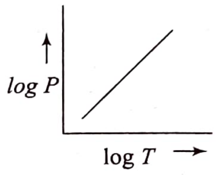
(a)



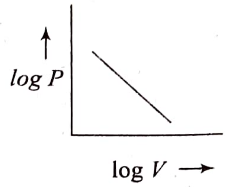
(b)



(c)

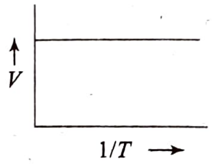


(d)

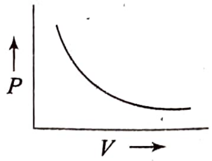


15. Which of the following plots is/are correct?

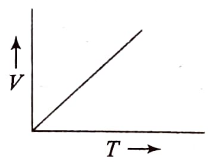
(a)



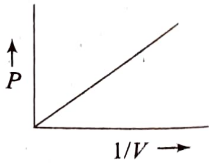
(b)



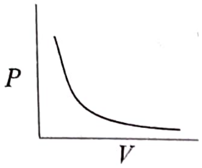
(c)

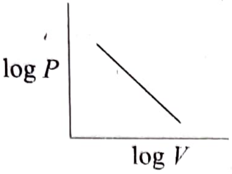


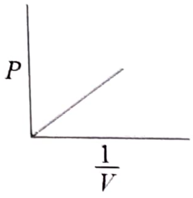
(d)

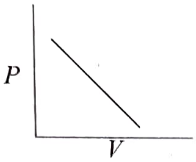


16. Which of the following curve does not represent Boyle's law?

(a)


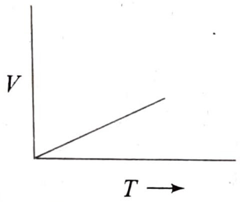
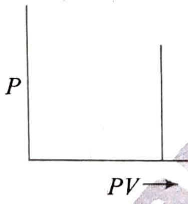
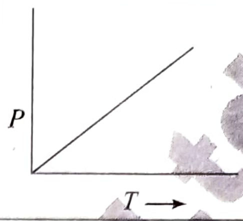
(b)


(c)


(d)


Matching Column Type

17. Match the following:

	Column I		Column II
a.	Boyle's law	p.	
b.	Charles' law	q.	
c.	Gay-Lussac's law	r.	

Integer Type

18. What is the volume of a sample of oxygen at a pressure of 3.1 bar if its volume at 1 bar is 3.15 L at the same temperature?

19. A graph of log P *vs* log(1/V) is drawn for a fixed amount of gas at constant temperature. If the proportionality constant k is 10.23, find the interact along y-axis.

Comprehension Type

Gaseous pressure is measured by barometer. The barometric tube must be exactly vertical, otherwise the pressure reading will not be accurate.

A 10 cm column of air is trapped by a column of Hg of 8 cm long. The capillary tube is horizontally fixed at 1 atm pressure. Calculate the length of air column when the tube is fixed at same temperature.

20. The pressure of air measured when tube is held vertically with open end up is:
(a) 11.61 cm (b) 9.05 cm
(c) 11.18 cm (d) 10.18 cm

21. The pressure of air (in cm) when tube is held vertically with open end down.
(a) 11.61 (b) 9.6 (c) 11.18 (d) 10.3

22. The pressure of air (in cm) when tube is held at 45° from horizontal with open end up.
(a) 9.3 (b) 10.3 (c) 11.3 (d) 11.61

Answers Key

Subjective Type

1. (a) No (b) 44.71°C **2.** (a) 3.31 atm (b) 3.1 litres
3. 9.37% of v_i

Single Correct Answer Type

5. (c) **6.** (b) **7.** (a) **8.** (b) **9.** (c)
10. (b) **11.** (b)

Multiple Correct Answers Type

12. (a, b, c) **13.** (a, c)
14. (a, b, c, d) **15.** (b, c, d) **16.** (d)

Matching Column Type

17. (a → q), (b → p), (c → r)

Integer Type

18. (1) **19.** (1)

Comprehension Type

20. (b) **21.** (c) **22.** (a)

DPP 4.2

Ideal Gas Equation

Subjective Type

1. What should be the percentage increase in pressure for a 5% decrease in volume of a gas at constant temperature?
2. The pressure exerted by 12 g of an ideal gas at temperature t°C in a vessel of volume V litre is one atm. When the temperature is increased by 10 degree at the same volume, the pressure increases by 10%. Calculate the temperature t and volume V. (Molar mass of the gas = 120).
3. 0.553 g of a boron-hydrogen compound created a pressure of 0.658 atm in a bulb of 407 mL at 100°C. Analysis showed it to be 85.7% boron. Calculate its molecular formula.
4. Calculate % of 'free volume' available in 1 mol gaseous water at 1.0 atm and 100°C. Density of liquid water at 100°C is 0.958 g/mol.

Single Correct Answer Type

5. A mixture of $NH_3(g)$ and $N_2H_4(g)$ is placed in a sealed container at 300 K. The pressure within the container is 0.6 atm. The container is heated to 1000 K where the two gases undergo decomposition reactions.

$$2NH_3(g) \rightarrow N_2(g) + 3H_2(g) \quad \text{and}$$
$$N_2H_4(g) \rightarrow N_2(g) + 2H_2(g)$$

The pressure of the container at this stage become 4.8 atm. The mole per cent of $NH_3(g)$ in the original mixture was

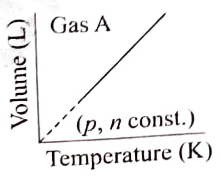
(a) 40 (b) 50 (c) 60 (d) 70

6. At 10°C, the density of a fixed mass of an ideal gas divided by its pressure is X. At 110°C, this ratio would be:

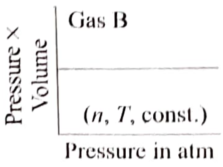
(a) $\frac{10X}{110}$ (b) $\frac{283X}{383}$ (c) X (d) $\frac{383}{283}X$

7. Which of these gases exhibits behaviour that deviates most significantly from that expected for an ideal gas?

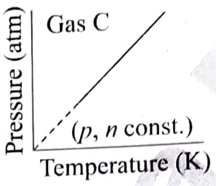
(a)



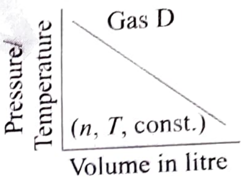
(b)



(c)

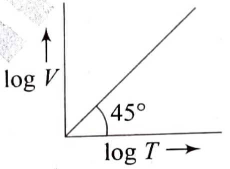


(d)

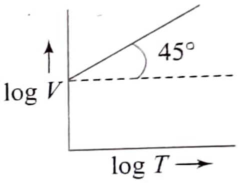


8. Ten moles of an ideal gas are filled in a closed vessel. The vessel has cylinder and piston type arrangement and pressure of the gas remains constant at 0.821 atm. Which of the following graph represents correct variation of log V vs log T? (V = Volume in litre and T = Temperature in Kelvin)

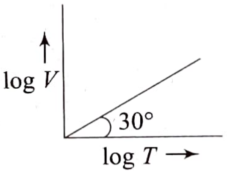
(a)



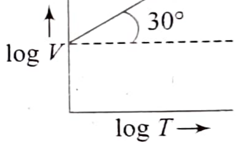
(b)



(c)



(d)



9. For a definite amount of gas, pressure and volume are increased to triple of the initial amount. Therefore
   - (a) Temperature increased to nine times of its initial value
   - (b) Temperature increased to thrice of its initial value
   - (c) Temperature remain unaltered
   - (d) Temperature reduced to thrice of its initial value

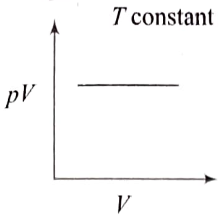
Multiple Correct Answers Type

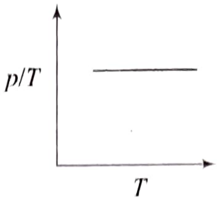
10. Equations of state of an ideal gas is/are

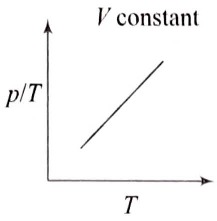
(a) $pV = (1/3)\, mN$ (b) $pV = nRT$
(c) $p = \rho RT/M$ (d) $p = 3\, Mk/2\, V$

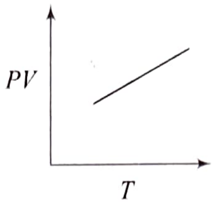
11. Which of the following statements are not correct?
   - (a) The abbreviation STP stands for standard temperature and pressure where temperature is 25°C and pressure is 1 atm.
   - (b) Two grams of hydrogen contains as many molecules as in 44 g of carbon dioxide.
   - (c) For an ideal gas at constant temperature, the ratio ρ/p is dependent on pressure.
   - (d) For an ideal gas at constant volume, the plot of p/T versus T is linear with slope having a nonzero.

12. Which of the following graphs represent the behaviour of an ideal gas?

(a) 

(b) 

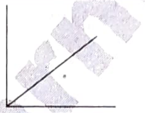
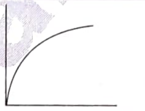
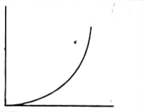
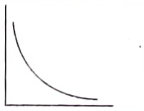
(c) 

(d) 

13. The temperature of ideal gas can be increased by
- (a) decreasing the volume and pressure but keeping the amount constant
- (b) increasing the pressure but keeping the volume and amount constant
- (c) decreasing the amount but keeping the volume and pressure constant
- (d) increasing the amount but keeping the volume and pressure constant

Matching Column Type

14. Match the following:

Column I		Column II	
a.	Plot of $1/V^2$ against P for ideal gas at constant temperature and number of moles	p.	
b.	Plot of V against $1/T$ for ideal gas at constant pressure and number of moles	q.	
c.	Plot of P against T for ideal gas at constant volume and number of moles	r.	
d.	Plot of V against $1/P^2$ for ideal gas at constant temperature and number of moles	s.	

Integer Type

15. If the volume of 2 moles of an ideal gas at 540 K is 44.8 L, its pressure will be x atm. The value of x is ....

16. For 6.023×10^{23} molecules of an ideal gas has $PV/T = x$ cal. The value of 'x' is ....

Comprehension Type

A gas that follows Boyle's law, Charles' law and Avogadro's law strictly is called an ideal gas. Such a gas is hypothetical. It is assumed that intermolecular forces are not present between the molecules of an ideal gas. Real gases follow these laws only under certain specific conditions when the forces of interaction are practically negligible, i.e., at low pressure and very high temperature. In all other situations, they deviate from ideal behaviour.

$$PV = nRT$$

This equation relates the variables P, V, T and n and is called the ideal gas equation.

17. A 100 mL flask contained H_2 at 200 Torr, and a 200 mL flask contained He 100 Torr. The two flasks were then connected so that each gas filled their combined volume. Assuming no change in temperature, total pressure is
(a) 300 Torr (b) 66.66 Torr
(c) 150 Torr (d) 133.33 Torr

18. A 3.00 L oxygen gas is collected over water at 27°C when the barometric pressure is 787 Torr. If vapour pressure of water is 27 Torr at 27°C, moles of O_2 gas will be?
(a) 0.122 (b) 0.126 (c) 0.004 (d) 0.152

19. A mixture of C_3H_8 and CH_4 exerts a pressure of 320 mm Hg at temperature T K in a v litre flask. On complete combustion, gaseous mixture contains CO_2 only and exerts a pressure of 448 mm Hg under identical conditions. Hence, mole fraction of C_3H_8 in the mixture is
(a) 0.2 (b) 0.8 (c) 0.25 (d) 0.75

20. A mixture of nitrogen and oxygen has a density of 1.00 g L^{-1} and the average molecular weight of 31.2 g mol^{-1} at 27°C and 600 mm Hg pressure. The mole fraction of nitrogen assuming ideal gas behaviour is
(a) 0.78 (b) 0.60 (c) 0.40 (d) 0.22

Answers Key

Subjective Type

1. 5.26%
2. 100 K, 0.82 litre
3. B_5H_9
4. 99.93%

Single Correct Answer Type

5. (c) 6. (b) 7. (d) 8. (a) 9. (a)

Multiple Correct Answers Type

10. (a, b, c) 11. (a, c, d) 12. (a, b)
13. (b, c)

Matching Column Type

14. (a → r), (b → s), (c → p), (d → q)

Integer Type

15. (2) 16. (2)

Comprehension Type

17. (d) 18. (a) 19. (a) 20. (d)

DPP 4.3

Dalton's Law of Partial Pressure, Graham's Law of Diffusion/ Effusion

Subjective Type

1. Calculate the total pressure in a 10 litre cylinder which contains 0.4 g of helium, 1.6 g of oxygen and 1.4 g of nitrogen at 27°C. Also calculate the partial pressure of helium gas in the cylinder. Assume ideal behaviour of gases. Given, $R = 0.082$ litre-atm K^{-1} mol^{-1}.
2. Equal masses of CH_4 and O_2 are mixed in an empty container of one litre at 27°C. Calculate the:
   (a) fraction of total pressure exerted by 2 g.
   (b) total pressure if the masses of gases are 32 g each.
3. Two gases A and B having molar mass 60 and 45 respectively are enclosed in a vessel. The mass of A is 0.50 g and that of B 0.2 g. The total pressure of the mixture is 750 mm. Calculate partial pressure of the two gases.
4. Pure O_2 diffuses through an aperture in 224 seconds, whereas mixture of O_2 and another gas containing 80% O_2 diffuses from the same in 234 sec. What is molar mass of gas?
5. A mixture containing 1.12 litre of D_2 and 2.24 litre of H_2 at NTP is taken inside a bulb connected to another bulb through a stop cock with a small opening. The second bulb is fully evacuated. The stop cock is opened for a certain time and then closed. The first bulb is now found to contain 0.10 g of D_2. Determine the % by mass of the gases in second bulb.

Single Correct Answer Type

6. Three grams of helium diffuses from a container in 15 min. The mass of sulphur dioxide diffusing from the same container over the same time interval will be
   (a) 3 g (b) 6 g (c) 9 g (d) 12 g
7. The volume X of H_2 gas effuses through a hole in a container in 5 seconds. The time taken for the effusion of the same volume of the specified gas under identical conditions is
   (a) 10 seconds: He (b) 20 seconds: O_2
   (c) 25 seconds: CO (d) 55 seconds: CO_2
8. The degree of dissociation (α) of the reaction $A_2(g) \rightleftharpoons 2A(g)$ in terms of rate of diffusion (r_{mix}) of equilibrium mixture and that of a reference gas C is given by
   (a) $\alpha = \left(\frac{M_{A_2}}{M_X}\right)\left(\frac{r_{mix}}{r_X}\right)^2 - 1$
   (b) $\alpha = \left(\frac{M_{A_2}}{M_X}\right)\left(\frac{r_X}{r_{mix}}\right)^2 - 1$
   (c) $\alpha = \left(\frac{M_X}{M_{A_2}}\right)\left(\frac{r_{mix}}{r_X}\right)^2 - 1$
   (d) $\alpha = \left(\frac{M_X}{M_{A_2}}\right)\left(\frac{r_{mix}}{r_X}\right)^2 - 1$

   where M stands for the respective molar masses.
9. If X_M, X_P and X_V are mole fraction, pressure fraction and volume fraction respectively of a gaseous mixture, then
   (a) $X_M = \frac{1}{X_P} = \frac{1}{X_V}$ (b) $\frac{1}{X_M} = X_P = \frac{1}{X_V}$
   (c) $X_M = X_P = X_V$ (d) $\frac{1}{X_M} = \frac{1}{X_P} = \frac{1}{X_V}$
10. 1000 ml of a gas A at 600 torr and 500 ml of gas B at 800 torr are placed in a 2L flask. The final pressure will be
    (a) 2000 torr (b) 1000 torr
    (c) 500 torr (d) 1400 torr

Multiple Correct Answers Type

11. To which of the following mixtures Dalton's law is not applicable?
    (a) CO_2 and CO at room temperature
    (b) Ammonia and hydrogen chloride at room temperature
    (c) NH_3 and steam at room temperature
    (d) He and H_2
12. Which of the following depicts Graham's law?
    (a) $\frac{r_1}{r_2} = \frac{P_1}{P_2} \times \sqrt{\frac{M_2}{M_1}}$ (b) $\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$
    (c) $\frac{r_1}{r_2} = \sqrt{\frac{d_2}{d_1}}$ (d) $\frac{r_1}{r_2} = \frac{P_2}{P_1} \times \sqrt{\frac{M_2}{M_1}}$
13. 20 g of hydrogen and 128 g of oxygen are contained in a 20 L flask at 200°C. Calculate the total pressure of the mixture.
    (a) 27.15 atm (b) 2.715 atm
    (c) 20634 mm (d) 27.50×10^6 dynes cm^{-2}

14. A balloon filled with ethylene is pricked with a needle and quickly dropped in a tank of H_2 gas under identical conditions. After a while, the balloon will not

(a) Shrink (b) Enlarge

(c) Completely collapse (d) Remain unchanged in size

Matching Column Type

15. Match the following:

Column I		Column II	
a.	At definite volume and temperature total pressure of gas	p.	Changes with the change in temperature
b.	The ratio of densities of moist air to the density of dry air at the definite temperature and pressure	q.	Changes with change in no. of moles
c.	The value of $\frac{p_{H_2O}}{p^o_{H_2O}}$	r.	Ideal gases
d.	Dalton's law of partial pressure	s.	Lesser than one

Integer Type

16. A mixture of non-reacting gases exert a pressure of 5 atm. If one of the gases occupy 40% volume of the mixture, what would be its partial pressure in atm?

17. How many times faster the helium will diffuse as compared to methane under identical condition of temperature and pressure?

Comprehension Type

Diffusion in gases is attributed to the rapid movement of gas molecules and the existence of a large empty space between any two molecules. When the two gases are brought in contact with each other, the molecules of one gas move into the empty spaces of the other gas gradually, and this ultimately leads to the formation of a homogeneous mixture.

Effusion is a process by which a gas under pressure escapes from the vessel through a small opening or orifice. Air escaping from a punctured tyre or football bladder and perfume molecules escaping through an atomizer are common examples of effusion. The process of effusion is always followed by diffusion.

18. To a given container having a pore of definite size, gas A (mol. wt = 81) is filled till the final pressure become 10 atm. It was seen in 50 minutes 10 gm of A was effused out. Now the container was completely evacuated and filled with gas B (mol. wt = 100) till the final pressure become 20 atm. In 75 minutes how many gm of B will be effused out?

(a) $\frac{100}{6}$ g (b) $\frac{100}{3}$ g

(c) $\frac{200}{3}$ g (d) $\frac{250}{3}$ g

19. In an effusion experiment, it required 40 s for a certain number of moles of a gas of unknown molar mass to pass through a small orifice into a vacuum. Under the same conditions, 16 s were required for the same number of moles of O_2 to effuse. What is the molar mass of the unknown gas?

(a) 5.1 g/mol (b) 12.8 g/mol

(c) 80 g/mol (d) 200 g/mol

20. A certain gas effuses out of two different vessels *A* and *B*. *A* has a circular orifice while *B* has a square orifice of length equal to the radius of the orifice of vessel *A*. The ratio of rate of diffusion of the gas from vessel *A* to that from vessel *B* is

(a) $\pi : 1$ (b) $1 : \pi$

(c) 1 : 1 (d) 3 : 2

21. A gas with formula C_nH_{2n+2} diffuses through the porous plug at a rate one-sixth of the rate of diffusion of hydrogen gas under similar condition. The formula of gas is

(a) C_2H_6 (b) $C_{10}H_{22}$

(c) C_5H_{12} (d) C_9H_{14}

Answers Key

Subjective Type

1. 0.492 atm, 0.246 atm

2. (a) $\frac{1}{3}$ (b) 73.89 atm

3. 260.77 mm **4.** 46.6

5. 41.66%, 58.33%

Single Correct Answer Type

6. (d) **7.** (b) **8.** (a) **9.** (c) **10.** (c)

Multiple Correct Answers Type

11. (b, c) **12.** (a, b, c) **13.** (a, c, d)

14. (a, c, d)

Matching Column Type

15. (a → q), (b → s), (c → p, s), (d → p, q, r)

Integer Type

16. (2) **17.** (2)

Comprehension Type

18. (b) **19.** (d) **20.** (a) **21.** (c)

DPP 4.4

Kinetic Theory of Gases, Maxwell's Distribution of Speeds

Subjective Type

1. Calculate the root mean square speed and average speed for a sample of gas having 5, 10 and 15 molecules each one in a set is moving with a speed of 15×10^5, 5×10^2 and 10×10^2 m s^{-1} respectively.

2. A glass bulb of 1 litre capacity contains 2×10^{21} molecules of nitrogen exerting pressure of 7.57×10^3 Nm^{-2}. Calculate the root mean square speed and the temperature of gas molecules. If the ratio of u_{MP} to u_{rms} is 0.82, calculate u_{MP} for these molecules at this temperature.

3. Two bulbs A and B of equal capacity are filled with He and SO_2 respectively, at the same temperature.
   (i) If the pressure in two bulbs is same, calculate ratio of u_{rms} for them?
   (ii) At what temperature velocity of SO_2 becomes half of the speed of He molecules at 27°C?
   (iii) How will the speeds be effected if volume of B becomes four times?
   (iv) How will the speeds be effected if half of the molecules of SO_2 are removed from B?

4. The kinetic molecular theory attributes an average translational kinetic energy of $\frac{3}{2}\frac{RT}{N}$ to each particle.

   What rms speed would a mist particle of mass 10^{-12} g have at room temperature (27°C) according to kinetic theory of gases?

5. A bottle contains 1.0 mol He(g) and a second bottle contains 1.0 mol Ar(g) at the same temperature. At this temperature, the root mean square speed of He is 1477 m s^{-1} and that of Ar is 467 m s^{-1}. What is the ratio of the number of He atoms in the first bottle to the number of Ar atoms in the second bottle having these speeds? Assume that both gases behave ideally?

Single Correct Answer Type

6. The value of $(pV_m)_{p \to 0}$ at 0°C for an ideal gas is
   (a) 22.414 bar dm^3 (b) 22.71 bar dm^3
   (c) 23.414 bar dm^3 (d) 25.0 bar dm^3

7. Which of the following expressions is correct for an ideal gas?
   (a) $p = \frac{2}{3}\frac{V}{N}\bar{E}$ (b) $p = \frac{3}{2}\frac{V}{N}\bar{E}$
   (c) $p = \frac{2}{3}\frac{N}{V}\bar{E}$ (d) $p = \frac{3}{2}\frac{N}{V}\bar{E}$

8. The relative ratio of $u_{rms} : u_{av} : u_{mp}$ at a given temperature is
   (a) $\sqrt{3} : \sqrt{56/22} : \sqrt{2}$ (b) $\sqrt{56/22} : \sqrt{2} : \sqrt{3}$
   (c) $\sqrt{3} : \sqrt{2} : \sqrt{56/22}$ (d) $\sqrt{2} : \sqrt{56/22} : \sqrt{3}$

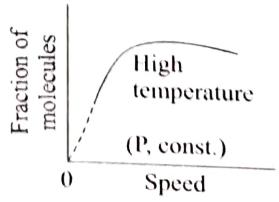
9. The most probable speed of an ideal gaseous molecules at 27°C is 0.3 m s^{-1}. The average speed at 927°C would be
   (a) 0.3 m s^{-1} (b) 0.6 m s^{-1}
   (c) 0.9 m s^{-1} (d) 1.2 m s^{-1}

10. The root square speed of a gaseous molecules is given as $u_{rms} = \sqrt{3p/\rho}$. This shows that at a given temperature
    (a) $u_{rms} \propto \sqrt{p}$ (b) $u_{rms} \propto \sqrt{1/\rho}$
    (c) $u_{rms} \propto \sqrt{pV_m}$ (d) $u_{rms} \propto \sqrt{p/V_m}$

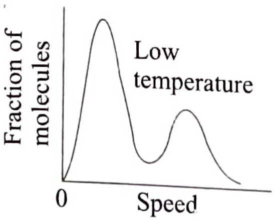
11. Which of the following expressions correctly represents the relationship between the average kinetic energy of CO and N_2 molecules at the same temperature?
    (a) $\bar{E}(CO) > \bar{E}(N_2)$
    (b) $\bar{E}(CO) < \bar{E}(N_2)$
    (c) $\bar{E}(CO) = \bar{E}(N_2)$
    (d) Cannot be predicted unless volume of the gases are given

12. A mixture containing Ne and Ar in a vessel at 250 K has a total translation kinetic energy = 3 kJ. The total mass of mixture is 30 g. What is the mass % of Ar in mixture?
    (a) 28.3 (b) 71.7
    (c) 50.3 (d) 30.2

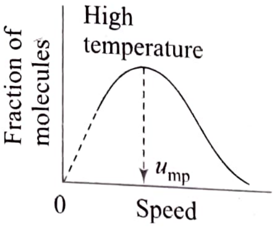
13. Which of the following graph is in accordance to the Maxwell distribution of molecular and its dependence on temperature?

    (a) 

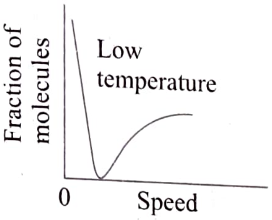
(b)



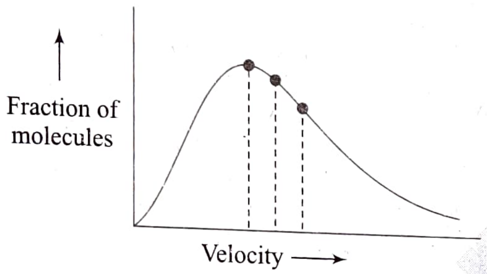
(c)



(d)



14. Fraction of molecules are plotted against velocity of molecules, according to Maxwell-Boltzmann distribution law. The velocity corresponding to the points X, Y and Z are:



(a) v_{mp}, v_{av}, v_{rms}
(b) v_{av}, v_{rms}, v_{mp}
(c) v_{rms}, v_{av}, v_{mp}
(d) v_{mp}, v_{rms}, v_{mp}

Here v_{mp} = Most probable velocity
v_{av} = Average velocity
v_{rms} = Root mean square velocity

Multiple Correct Answers Type

15. Which of the following facts regarding an ideal gas is/are correct?

(a) The mean square speed of gaseous molecules is directly proportional to the square root of Kelvin temperature.
(b) The mean square speed is inversely proportional to the molecular mass.
(c) The viscosity of a gas increases with increase in temperature.
(d) The viscosity of a gas is independent of its density.

16. Which of the following statement are not correct?

(a) The expression of kinetic gas equation is $pV = \frac{1}{3}mN\overline{u^2}$.
(b) The symbols $\overline{u^2}$ and $\bar{u}^2$ represent one and the same physical quantity.
(c) The density of an ideal gas increases with increase in temperature provided its pressure is constant.
(d) The average kinetic energy of gaseous molecules depends only on temperature and nature of gaseous molecules.

17. Which of the following statements are correct?

(a) The average kinetic energy of a gas is independent of the molar mass of the gas.
(b) For a given gas at a constant temperature, the root means square speed of its molecules is greater that their average speed.
(c) For a given gas at a constant temperature, the root mean square speed of its molecules is greater than their most probable speed.
(d) For a given gas at a constant temperature, the average speed of its molecules is greater than their most probable speed.

18. Let u_{av}, u_{rms} and u_{mp} respectively denote the average speed, root mean square average speed and most probable speed in an ideal monatomic gas at kelvin temperature *T*. The mass of an atom is *m*. Then

(a) no atom can have a speed greater that $\sqrt{2}\ u_{rms}$.
(b) no atom can have a speed less that $u_{rms}/\sqrt{2}$.
(c) $u_{mp} < u_{av} < u_{rms}$
(d) the average kinetic energy of an atom is $(3/4)\ um_{mp}^2$.

Matching Column Type

19. Match the following:

	Column I		Column II
a.	If temperature of given gas is increased	p.	Average speed of gas will increase
b.	If the pressure of a given gas is increased at constant temperature	q.	Root mean square speed of gas molecules will increase
c.	If the density of a given gas is lowered at constant temperature	r.	Most probable speed of gas molecules will increase
d.	If the volume of a given gas is increased at constant temperature	s.	Speed of gas molecules will not change

Integer Type

20. What is the average speed of a molecule, having a molecular mass of 529.5 g mol^{-1} at temperature 100 K?

21. At 27°C, a gas contains 10 molecules traveling with a speed of 4 ms^{-1}, 20 molecules traveling with a speed of 7 $m\ s^{-1}$ and 40 molecules traveling with a speed of 8 $m\ s^{-1}$. Root mean square speed and most probable speed of the gas at 27°C.

Comprehension Type

The average kinetic energy of gas molecules can be calculated on the basis of the kinetic gas equation.

$$KE = \frac{3}{2}RT \quad \text{or} \quad KE = \frac{3}{2}kT$$

where $k = \dfrac{R}{N_A}$ (*k* is called the Boltzmann constant)

$$k = \frac{R}{N_A} = \frac{8.314\ J\ K^{-1}\ mol^{-1}}{6.022 \times 10^{23}\ mol^{-1}} = 1.301 \times 10^{-23}\ J\ s^{-1}$$

Since *R* or *K* are constants, it can be concluded that KE of gas is proportional to *T*.

22. At the same temperature and pressure which of the following gas will have highest KE per mol?

(a) H_2 (b) O_2 (c) CH_4 (d) Equal

23. At what temperature will the total KE of 0.30 mole of He be the same as the total KE of 0.40 mole Ar at 400 K?

(a) 533 K (b) 400 K (c) 346 K (d) 300 K

24. The average kinetic energy of an ideal gas per molecule in SI unit at 25°C will be

(a) 6.17×10^{-21} kJ (b) 6.17×10^{-21} J

(c) 6.17×10^{-20} J (d) 6.17×10^{-20} kJ

25. KE per unit volume is

(a) $\dfrac{3}{2}P$ (b) $\dfrac{3}{2}RT$ (c) $\dfrac{3\ RN}{2\ N_0}$ (d) $\dfrac{3\ RT}{2\ n}$

Answers Key

Subjective Type

1. 9.17×10^2 m sec^{-1}
2. 405.26 m sec^{-1}
3. (i) 4 (ii) 1200 K (iii) No effect (iv) No effect
4. 0.35 cm sec^{-1}
5. 467 : 1477

Single Correct Answer Type

6. (a) 7. (c) 8. (a) 9. (b) 10. (c)
11. (c) 12. (b) 13. (c) 14. (a)

Multiple Correct Answers Type

15. (b, c, d) 16. (a, b, c) 17. (a, b)
18. (c, d)

Matching Column Type

19. (a → p, q, r), (b → s), (c → p, q, r), (d → s)

Integer Type

20. (2) 21. (6)

Comprehension Type

22. (d) 23. (a) 24. (b) 25. (a)

DPP 4.5

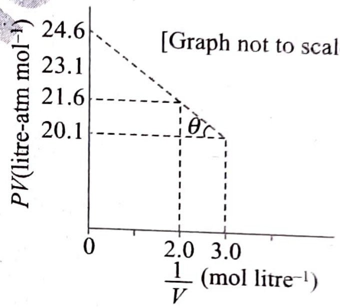
van der Waals Gas Equation and Other Equations of State for Real Gases

Subjective Type

1. Calculate the volume correction and pressure correction for 4.4 g CO_2 kept in 1 litre flask. Given $a = 3.6$ atm L^2 mol^{-2} and $b = 0.04$ L mol^{-1} for CO_2.
2. The value of 'b' for steam is 0.0305 litre mol^{-1}. The density of liquid water is 0.958 g/mL at 100°C. What % of volume of water molecules occupy in gaseous phase of water in liquid phase?
3. Calculate the pressure exerted by 5 mole of CO_2 in one litre vessel at 47°C using van der Waals equation. Also report the pressure of gas if it behaves ideally in nature. Given that $a = 3.592$ atm litre^2 mol^{-2}, $b = 0.0427$ litre mol^{-1}.
4. Calculate the compressibility factor for CO_2, if one mole of it occupies 0.4 litre at 300 K and 40 atm. Comment on the result.
5. The compressibility factor for a given real gas is 0.927 at 273 K and 100 atm. Calculate the mass of gas required to fill a gas cylinder of 100 litre capacity under given conditions. [Molar mass of gas = 30]

Single Correct Answer Type

6. At Boyle temperature, the value of compression factor Z $(= pV_m/RT = V_{real}/V_{ideal})$ has a value of one over a wide range of pressure. This is due to the fact that in the van der Waals equation
   (a) the constant a is negligible and not b
   (b) the constant b is negligible and not a
   (c) both the constants a and b are negligible
   (d) the effect product due to the molecular attraction compensates the effect produced to the molecular volume
7. Which of the following expressions between the van der Waals constant b and the radius r of spherical molecules is correct?
   (a) $b = \left(\frac{4}{3}\pi r^3\right)N_A$ (b) $b = 2\left(\frac{4}{3}\pi r^3\right)N_A$
   (c) $b = 3\left(\frac{4}{3}\pi r^3\right)N_A$ (d) $b = 4\left(\frac{4}{3}\pi r^3\right)N_A$
8. The value of compression factor of a van der Waals gas at critical point is
   (a) 8/27 (b) 27/8 (c) 3/8 (d) 8/3
9. The pressure exerted by 1 mole of CO_2 at 273 K, is 34.98 atm. assuming that volume occupied by CO_2 molecules is negligible. The value of van der Waals constant for attraction of CO_2 gas is:
   (a) 3.59 dm^6 atm mol^{-2} (b) 2.59 dm^6 atm mol^{-2}
   (c) 1.25 dm^6 atm mol^{-2} (d) 1.59 dm^6 atm mol^{-2}
10. For one mole of a van der Waals' gas when $b = 0$ and $T = 300$ K, the PV *vs.* $1/V$ plot is shown below. The value of the van der Waals constant a (atm litre^2 mol^{-2}) is:



   (a) 1.0 (b) 4.5 (c) 1.5 (d) 3.0

Multiple Correct Answers Type

11. Which of the following statements is/are correct?
   (a) The compression factor less that one is due to van der Waals constant a of a real gas
   (b) The compression factor more than one is due to the excluded volume of the gas
   (c) The excluded volume, which is represented by the van der Waals constant b, is equal to the volume occupied by the molecules of 1 mol of a gas.
   (d) At Boyle temperature, the effects caused by the van der Waals constant a and b compensate each other causing the gas to behave ideally over a wide range of pressure.
12. Which of the following statements are correct?
   (a) The van der Waals constant b is four times the volume occupied by molecules in one mole of a gas.
   (b) A gas having comparatively higher value of van der Waals constant a can be liquefied more easily.
   (c) The term $V_m - b$ in van der Waals equation represents the available volume where molecules of the gas can move.
   (d) The compression factor of an ideal gas is independent of temperature and pressure of the gas.

13. Which of the following statements are not correct?
   (a) A real gas is expected to deviate from ideal bahaviour at high temperature and low pressure.
   (b) The unit of van der Waals constant a in SI units Pa m^3 mol^{-1}.
   (c) The unit of van der Waals constant b in SI units is m^3 mol.
   (d) The van der Waals constant b is two times the actual volume occupied by molecules of 1 mol of gas.

14. Which of the following statements are correct?
   (a) For a real gas, the compression factor Z is defined as $V_{\text{real}}/V_{\text{ideal}}$.
   (b) At low pressure, the variation of compression factor with pressure can be explained from van der Waals equation when the term b is ignored in comparison to the term V_m.
   (c) At high pressure, the variation of compression factor with pressure can be explained from the van der Waals equation when the term a is ignored in comparison to the term V_m.
   (d) The value 6.022×10^{23} mol^{-1} is assigned to Avogadro constant.

15. Which of the following statements is/are correct about real gases?
   (a) The molecules do cause attractive forces on each another.
   (b) They obey gas laws at low temperature and high pressure
   (c) They show deviations from ideal behaviour
   (d) The molecules have negligible mass

16. At very high pressure, the van der Waals equation reduces to
   (a) $PV = RT + Pb$
   (b) $PV = \dfrac{aRT}{V^2}$
   (c) $P = \dfrac{RT}{V - b}$
   (d) $PV = RT - \dfrac{a}{V}$

Matching Column Type

17. Column II gives the values of γ (= $C_{p,m}/C_{V,m}$) at high temperature of gases which are shown in Column I. Identify the gas with the corresponding γ value.

	Column I		Column II
a.	Real gas at high pressure	p.	$PV = RT + Pb$
b.	Force of attraction among gas molecules is negligible	q.	$PV = nRT$
c.	At high temperature and low pressure	r.	$Z = 1$
d.	Real gas at N.T.P	s.	$\left(P + \dfrac{an^2}{V^2}\right)(V - nb) = nRT$

Integer Type

18. The value of compressibility factor (Z) for an ideal gas is …… .

19. The ratio of excluded volume (b) to molar volume of a gas molecule is …… .

Comprehension Type

The behaviour of a real gas may be represented by Berthelot's equation

$$p = \frac{RT}{V_m - b} - \frac{a}{TV_m^2}$$

20. The unit of constant a is
   (a) Pa m^6 mol^{-2}
   (b) Pa m^3 mol^{-1}
   (c) Pa m^6 K mol^{-2}
   (d) atm L^2 mol^{-2}

21. If the Berthelot's equation is transformed into the virial equation in V_m, the second virial coefficient will be given by the expression.
   (a) $B = b - \dfrac{a}{RT}$
   (b) $B = b - \dfrac{a}{RT^2}$
   (c) $B = a - \dfrac{b}{RT}$
   (d) $B = a - \dfrac{b}{RT^2}$

22. The Boyle temperature for the Berthelot's equation is given by the expression
   (a) $T_B = 1/Rb$
   (b) $T_B = a/\sqrt{Rb}$
   (c) $T_B = \sqrt{a/Rb}$
   (d) $T_B = b/Ra$

Answers Key

Subjective Type

1. 0.004 litre
2. 40%
3. 77.218 atm
4. 0.65
5. 14.439 kg

Single Correct Answer Type

6. (d) 7. (d) 8. (c) 9. (a) 10. (c)

Multiple Correct Answers Type

11. (a, b, d)
12. (a, b, c, d)
13. (a, b, d)
14. (a, b, d)
15. (a, c)
16. (a, c)

Matching Column Type

17. (a → p), (b → p), (c → q, r), (d → s)

Integer Type

18. (1) 19. (4)

Comprehension Type

20. (c) 21. (b) 22. (c)

DPP 4.6

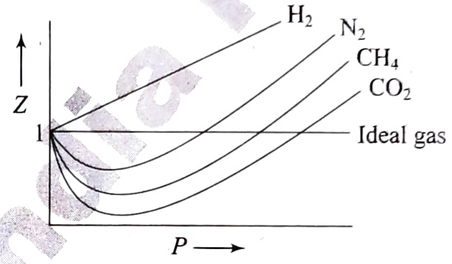
Liquefaction of Gases, Inversion Temperature and Joule Thomson Effect

Subjective Type

1. Calculate van der Waals constant a and b if critical temperature and critical pressure are 30°C and 72 atm respectively.
2. Reduced temperature and reduced volume of benzene are 0.7277 and 0.40 respectively. Calculate reduced pressure of benzene.
3. van der Waals constant a and b for hydrogen are 0.246 L^2 atm mol^{-2} and 0.0267 L mol^{-1} respectively. Calculate inversion temperature and Boyle's temperature of H_2 gas.

Single Correct Answer Type

4. The critical temperature of O_2 is less than H_2O because the H_2O molecules have:
   (a) Fewer electrons than O_2
   (b) Two covalent bonds
   (c) V-shaped structure
   (d) Dipole moment
5. It is easier to liquefy oxygen than hydrogen because:
   (a) oxygen has a higher critical temperature and lower inversion temperature than hydrogen
   (b) oxygen has a lower critical temperature and higher inversion temperature than hydrogen
   (c) oxygen has a higher critical temperature and a higher inversion temperature than hydrogen
   (d) the critical temperature and inversion temperature of oxygen is very low
6. The mean free path (λ) of a gas sample is given by:
   (a) $\lambda = \sqrt{2}\,\pi\sigma^2 N$ (b) $\lambda = \dfrac{1}{\sqrt{2}\,\pi\sigma^2 N}$
   (c) $\lambda = \sqrt{2}\,\pi u\sigma^2 N$ (d) none of these
7. The ratio of Boyle's temperature and critical temperature for a gas is:
   (a) 8/27 (b) 27/8 (c) 1/2 (d) 2/1
8. The gases showing heating and cooling effect during Joule-Thomson's experiment have Joule-Thomson coefficient:
   (a) +ve and –ve respectively
   (b) –ve and +ve respectively
   (c) +ve
   (d) –ve
9. Compressibility factor $\left(Z = \dfrac{PV}{nRT}\right)$ is plotted against pressure:



   What is the correct order of liquefiability of the gases shown in the above graph?
   (a) $H_2 < N_2 < CH_4 < CO_2$ (b) $CO_2 < CH_4 < N_2 < H_2$
   (c) $H_2 < CH_4 < N_2 < CO_2$ (d) $CH_4 < H_2 < N_2 < CO_2$

Multiple Correct Answers Type

10. Which of the following facts regarding mean free path of gaseous molecules is/are correct?
    (a) Mean free path is directly proportional to Kelvin temperature provided pressure of the gas is held constant.
    (b) Mean free path is directly proportional to pressure provided temperature of the gas is held constant.
    (c) Mean free path is inversely proportional to the molecular diameter.
    (d) Mean free path is inversely proportional to the number of molecules per unit volume of the gas.
11. Which of the following statements is/are correct?
    (a) The value of $C_{p,m}/C_{V,m}$ (where C stands for heat capacity) of gaseous molecules decreases with increase in the number of atoms in the gaseous molecule.
    (b) The molar heat capacity of diatomic molecules at low temperature is about 3.5 R.
    (c) The molar average energy of helium gas is 1.5 RT.
    (d) The average vibrational energy of a diatomic molecule is $(1/2)kT$.
12. Which of the following statements are not correct?
    (a) The value of $C_p - C_V$ for one mole of an ideal gas is equal to R.
    (b) The value of C_p/C_V for one mole of an ideal (monatomic) gas is equal to 7/5.

(c) The value of $C_{V,m}$ for a monatomic gases is $(3/2)R$.

(d) The value of γ (= ratio of heat capacities) of gases increases with increase in the atomicity of gaseous molecule.

Matching Column Type

13. Match the following:

	Column I		Column II
a.	Liquefaction of gas	p.	$T < T_C$
b.	Impossible liquefaction of gas	q.	$T > T_C$
c.	Condensed vapour	r.	$P > P_C$
d.	Super critical fluid	s.	$P < P_C$

Integer Type

14. The ratio of the inversion temperature of a gas to its Boyle temperature is

Comprehension Type

At critical temperature and pressure, the van der Waals equation may be written as

$$V_m^3 - \left(b + \frac{RT_c}{p_c}\right)V_m^2 + \frac{a}{p_c}V_m - \frac{ab}{p_c} = 0$$

At these conditions, the above expression yields three identical and real roots. Thus, the above expression is equivalent to $(V_m - V_c)^3 = 0$

15. The expression of b in terms of V_c is

(a) $b = V_c/2$ (b) $b = V_c/3$

(c) $b = V_c/4$ (d) $b = V_c/6$

16. The expression of a in terms of p_c and T_c is

(a) $a = 27(RT_c)^2/64p_c$ (b) $a = 27RT_c/16p_c$

(c) $a = 64(RT_c)^2/p_c$ (d) $a = 27p_c/(RT_c)^2$

17. The value of p_cV_c/RT_c is

(a) 1/2 (b) 3/4 (c) 3/8 (d) 3/16

Answers Key

Subjective Type

1. 0.043 litre mol^{-1}, 3.59 litre^2 atm mol^{-2}

2. 10.350

3. 112.2 K

Single Correct Answer Type

4. (d) **5.** (c) **6.** (b) **7.** (b) **8.** (b)

9. (a)

Multiple Correct Answers Type

10. (a, d) **11.** (a, c) **12.** (b, d)

Matching Column Type

13. (a → p, r), (b → q), (c → p, s), (d → q, r)

Integer Type

14. (2)

Comprehension Type

15. (b) **16.** (a) **17.** (c)

DPP 4.7

Liquid State

Subjective Type

1. The normal boiling point of cyclohexane (enthalpy of vaporization: 30.08 kJ mol^{-1}) is 80.75°C. What will be its vapour pressure at 25°C?
2. In the determination of the surface tension of a liquid A by the drop-number method, equal volumes of A and water gave 60 and 20 drops, respectively. Calculate the surface tension of A if $\rho(A) = 0.86$ g cm^{-3} and ρ (water) = 0.996 g cm^{-3}. Given: $\gamma(H_2O) = 72.75 \times 10^{-3}$ N m^{-1}.
3. The viscosity of diethyl ether in millipoise is 2.84 at 0°C, 2.33 at 20°C. Calculate the activation energy of diethyl ether for viscous flow and its viscosity at 60°C.
4. The boiling point of n-Heptane is 36°C. Estimate its molar heat of vaporisation assuming that it obeys Trouton's rule.
5. The surface tension of water is 72.8 dynes cm^{-1}. Calculate the energy required to disperse one spherical drop of radius 3.0×10^{-3} mm.
6. The surface tension of water at 20°C is 72.8 dynes cm^{-1}. Calculate the minimum amount of work needed to increase the surface area of water from 2.0 to 5.0 cm^2 at this temperature.

Single Correct Answer Type

7. Which of the following statements regarding a liquid is not correct?
   (a) The vapour pressure a liquid increases with increase in temperature
   (b) The vapour pressure of a liquid decreases in the presence of a nonvolatile impurity
   (c) The variation of vapour pressure with temperature is given by
   $$\log p = \frac{\Delta_{vap} H_m}{2.303R}\frac{1}{T} + \text{constant}$$
   (d) The normal boiling point, the vapour pressure of a liquid is 1 atm.
8. Which of the following statements regarding a liquid is not correct?
   (a) The surface tension of a liquid is a temperature dependent property
   (b) The surface tension of a liquid is an intensive quantity
   (c) The SI unit of surface tension is N m^{-1}.
   (d) For a liquid, surface tension and surface energy have different values.
9. Which of the following statements regarding a liquid is not correct?
   (a) On variation sodium chloride in water, its surface tension decreases
   (b) The variation of surface tension of a liquid is given by the expression $\gamma(M\upsilon)^{2/3} = k(t_c - t - 6)$, where the various symbols have their usual meanings.
   (c) Soap is a surface active substance
   (d) 1 Nm^{-1} = 10^3 dyn cm^{-1}
10. Which of the following statements regarding a liquid is not correct?
   (a) The SI unit of viscosity is Pa s.
   (b) 1 Pa s = 10 Poise
   (c) The viscosity of a liquid decreases with increase in temperature
   (d) The viscosity of a gas decreases with increase in temperature
11. Which of the following statements is not correct?
   (a) Viscosity of ethanol is smaller than that of glycol
   (b) Viscosity of a liquid increases with impurities
   (c) The variation of viscosity is given by
   $$\eta = A \exp(-E/RT)$$
   (d) Capillary action is due to the surface tension of a liquid.
12. Increase in kinetic energy can overcome intermolecular forces of attraction. How will the viscosity of liquid be affected by the increase in temperature?
   (a) Increase
   (b) No effect
   (c) Decrease
   (d) No regular pattern will be followed
13. How does the surface tension of a liquid vary with increase in temperature?
   (a) Remains same
   (b) Decreases
   (c) Increases
   (d) No regular pattern is followed

Integer Type

14. Consider two liquids A and B such that A has half the surface tension and twice the density of B. If liquid A rises to a height of 2.0 cm in a capillary, what will be the height to which liquid B will rise in the same capillary?
15. Calculate the height to which water will rise in glass capillary if the radius of the tube is 0.02 cm. The surface tension of water is 72.8 dynes cm^{-1}.

Answers Key

Subjective Type

1. 112.4 mm Hg
2. 20.94×10^{-3} Nm^{-1}
3. 1.69 millipoise
4. 27.192 kJ mol^{-1}
5. 8.2×10^{-3} J
6. 218.4 ergs

Single Correct Answer Type

7. (c) **8.** (d) **9.** (a) **10.** (d) **11.** (c)
12. (c) **13.** (b)

Integer Type

14. (8) **15.** (7)

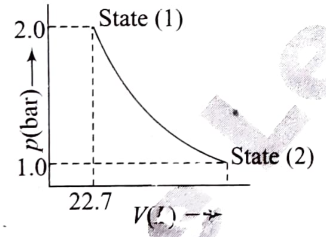
5 Thermodynamics

DPP 5.1

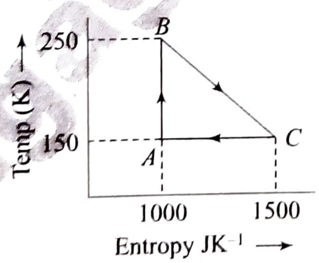
Basic Terms of Thermodynamics and Thermodynamic Processes

Subjective Type

1. 1.0 mol of a monoatomic ideal gas is expanded from state (1) to state (2) as shown in figure. Calculate the work done for the expansion of gas from state (1) to state (2) at 298 K.



2. What percent will be the efficiency of the reversible cycle shown in the figure?



3. 28.0 g of N_2 gas at 350 K and 25 atm was allowed to expand isothermally against a constant external pressure of 1 atm. Calculate w, q and ΔU for the gas.

4. 10 moles of an ideal gas expands isothermally and reversibly from a pressure of 10 atm to 2 atm at 300 K. What is the largest mass which can be lifted through a height of 1 meter in this expansion?

5. At 27°C, two moles of an ideal monoatomic gas occupy a volume V. The gas expands adiabatically to a volume $2V$. Calculate:
   (a) the final temperature of gas.
   (b) the change in internal energy.
   (c) the work done by the gas.

6. The molar enthalpy of vaporization of benzene at its boiling point (353 K) is 30.84 kJ mol^{-1}. What is the molar internal energy change? For how long would a 12V source need to supply a 0.5 A current in order to vaporize 7.8 g of the sample at its boiling point?

7. 130 g of Zn is dissolved in dilute sulphuric acid in an open beaker.
   (i) Find the work done in the process assuming isothermal operation.
   (ii) Dissolution of zinc is exothermic. If the system (i.e. acid with zinc dissolving in it) is at a steady temperature of 27°C, find the amount of water evaporated in the process assuming that no heat is lost to surroundings. Also evaluate the total work done in this case.

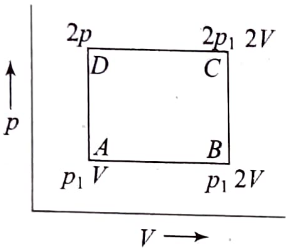
$$Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2\uparrow \;:\; \Delta H = -45 \text{ J/mol}$$
$$H_2O\,(l) \longrightarrow H_2O(g) \;:\; \Delta H = 2250 \text{ J/mol}$$

Single Correct Answer Type

8. Find the work done when 2 mole of hydrogen expand isothermally from 15 to 50 litres against a constant pressure of 1 atm at 25°C.
   (a) 848.2 cal (b) 848 kcal
   (c) 84.8 cal (d) 84.8 kcal

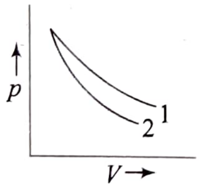
9. One mole of a monatomic ideal gas expands adiabatically at initial temperature T against a constant external pressure of 1 atm from one litre to three litres. The final temperature of the gas is
   (a) T (b) $T/3^{(5R/2)}$
   (c) $T - 2\text{K}/(1.5 \times 0.082)$ (d) $T + 2\text{K}/(1.5 \times 0.082)$

10. An ideal monatomic gas is taken round the cycle $ABCD$ as shown in the figure. The work done during the cycle is



   (a) pV (b) $2pV$ (c) $\frac{1}{2}pV$ (d) zero

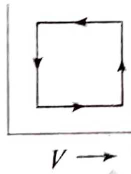
11. p-V plots for two gases during adiabatic processes are shown in figure. Plots 1 and 2 should correspond respectively to



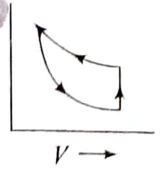
   (a) He and O_2 (b) O_2 and He
   (c) He and Ar (d) O_2 and N_2

12. What will be the nature of change in internal energy in case of processes shown below?

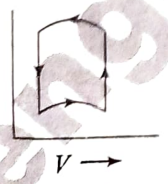
(I)



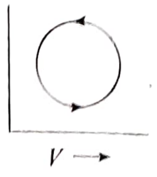
(II)



(III)



(IV)



   (a) +ve in all cases
   (b) –ve in all cases
   (c) –ve in I and III, and +ve in II and IV
   (d) zero in all cases

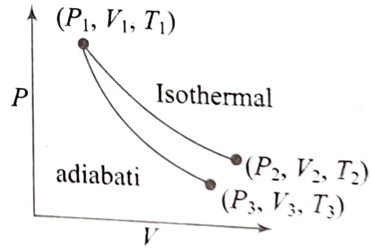
13. The work done in erg for the reversible expansion of one mole of an ideal gas from a volume of 10 litres to 20 litres at 25°C is
   (a) $2.303 \times 298 \times 0.082 \log 2$
   (b) $-298 \times 10^7 \times 8.13 \times 2.303 \log 2$
   (c) $-2.303 \times 298 \times 0.082 \log 0.5$
   (d) $2.303 \times 298 \times 2 \log 2$

14. Two mole of an ideal gas is heated at constant pressure of one atmosphere from 27°C to 127°C. If $C_{v,m} = 20 + 10^{-2}T$ JK^{-1} mol^{-1}, then q and ΔU for the process are respectively:
   (a) 6362.8 J, 4700 J (b) 3037.2 J, 4700 J
   (c) 7062.8, 5400 J (d) 3181.4 J. 2350 J

15. Determine which of the following reactions at constant pressure represent surrounding that do work on the system:
   (I) $4NH_3(g) + 7O_2(g) \longrightarrow 4NO_2(g) + 6H_2O(g)$
   (II) $CO(g) + 2H_2(g) \longrightarrow CH_3OH\ (l)$
   (III) $C(s, \text{graphite}) + H_2O(g) \longrightarrow CO(g) + H_2(g)$
   (IV) $H_2O(s) \longrightarrow H_2O\ (l)$
   (a) III, IV (b) II, III
   (c) II, IV (d) I and II, IV

Multiple Correct Answers Type

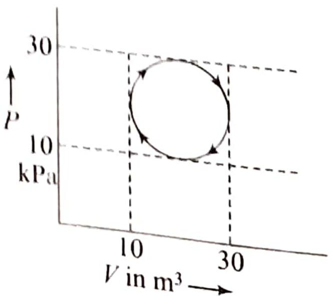
16. The reversible expansion of an ideal gas under adiabatic and isothermal conditions is shown in the figure. Which of the following statement(s) is (are) correct?



   (a) $T_1 = T_2$ (b) $T_3 > T_1$
   (c) $w_{\text{isothermal}} > w_{\text{adiabatic}}$ (d) $\Delta S_{\text{isothermal}} > \Delta S_{\text{adiabatic}}$

17. Among the following, the state function(s) is/are
   (a) Internal energy
   (b) Irreversible expansion work
   (c) Reversible expansion work
   (d) Molar enthalpy

18. Which one is not correct for a cyclic process as shown in figure?



   (a) $dU = 0$ (b) $q = -w$ (c) 314 J (d) 31.4 J

19. The work done during adiabatic expansion or compression of an ideal gas is given by:

(a) $n\,C_V\,\Delta T$ (b) $\dfrac{nR}{(\gamma-1)}(T_2-T_1)$

(c) $-nR\,P_{\text{ext}}\;-nR\,P_{\text{ext}}\left[\dfrac{T_2P_1-T_1P_2}{P_1P_2}\right]$

(d) $-2.303\,RT\log\dfrac{V_2}{V_1}$

20. N_2 gas is assumed to behave ideally. A given volume of N_2 originally at 373 K and 0.1013 MPa pressure is adiabatically compressed due to which its temperature rises to 673 K. Which of the following statements is/are correct?

(a) The change in internal energy is 6235.5 J mol^{-1}
(b) In this case the final internal pressure is equal to the external pressure
(c) The final pressure of N_2 is approximately 0.38 MPa
(d) The final pressure of N_2 is approximately 0.02 MPa

21. The work involved in a reversible adiabatic process of expansion of an ideal gas from P_1 and V_1 to P_2 and V_2 is given by

(a) $W=\dfrac{P_2V_2-P_1V_1}{\gamma-1}$

(b) $W=-nC_VT_1\left[1-\left(\dfrac{P_2}{P_1}\right)^{R/C_P}\right]$

(c) $W=nC_v(T_2-T_1)$

(d) $W=$ [efficiency of carnot cycle $\times\, a_{\text{absorbed}}$]

Matching Column Type

22. Match the following:

	Column I		Column II
A.	Adiabatic process	1.	Heat
B.	Isolated system	2.	At constant volume
C.	Isothermal change	3.	First law of thermodynamics
D.	Path function	4.	No exchange of energy and matter
E.	State function	5.	No transfer of heat
F.	$\Delta U = q$	6.	Constant temperature
G.	Law of conservation of energy	7.	Internal energy
H.	Reversible process	8.	$p_{\text{ext}=0}$
I.	Free expansion	9.	At constant pressure
J.	$\Delta H = q$	10.	Infinitely slow process which proceeds through a series of equilibrium states.
K.	Intensive property	11.	Entropy
L.	Extensive property	12.	Pressure
		13.	Specific heat

Integer Type

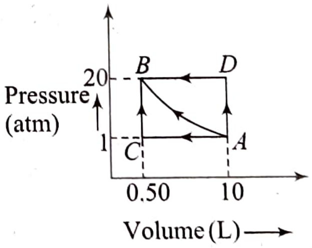
23. Calculate the work done by the reaction (in Litre-atm)

$$Fe(s) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + H_2(g)$$

When 0.3125 mole of H_2 gas is collected at 273 K at 1.0 atm.

Comprehension Type

Assume perfect gas behaviour in the following isotherm ($T = 313$ K)].



24. Number of moles of gas in this system at the start is
(a) 0.39 (b) 0.17 (c) 0.78 (d) 0.34

25. Work done on the gas along the path *DAC* is
(a) 0.96 kJ (b) +3.0 kJ (c) −5.0 kJ (d) +7.1 kJ

26. ΔU for path *ACB* is
(a) 19.7 kJ (b) zero (c) 51.2 kJ (d) 3.0 kJ

Answers Key

Subjective Type

1. −1717.46 J **2.** 25%
3. −2794.973 J, 2794.973 J, 0
4. 409.93
5. (a) 189 K (b) 4614.27 J (c) −2767 J
6. 514 sec.
7. (i) −1200 cal (ii) −1224 cal

Single Correct Answer Type

8. (a) **9.** (c) **10.** (a) **11.** (b)
12. (d) **13.** (b) **14.** (a) **15.** (d)

Multiple Correct Answers Type

16. (a, c, d) **17.** (a, d) **18.** (a, b, c) **19.** (a, b, c)
20. (a, b, c) **21.** (a, b, c)

Matching Column Type

22. (A→5), (B→4), (C→6), (D→1), (E→7,11,12), (F→2), (G→3), (H→10), (I→8), (J→9), (K→1, 12, 13), (L→7, 11)

Integer Type

23. (7)

Comprehension Type

24. (a) **25.** (a) **26.** (b)

DPP 5.2

Ist Law of Thermodynamics, Internal Energy, Enthalpy and Their Relation

Subjective Type

1. $CaCO_3$ exists in two forms, calcite and aragonite. The conversion of 1 mole of calcite to aragonite is accompanied by internal energy change equal to +0.21 kJ. Given that the densities of calcite and aragonite are 2.71 g cm^{-3} and 2.93 g cm^{-3} respectively, calculate the enthalpy change at the pressure of 1.0 bar.

2. The enthalpy change for the reaction, $Zn(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$, is -154.40 kJ mol^{-1}. The formation of 2 g of hydrogen expands the system by 22.4 litres at 1 atm pressure. What is the internal energy change of the reaction?

3. In an isolated container 100 ml of a liquid is taken at pressure of 1 bar. If the pressure is steeply increased to 100 bar the volume is decreased by 1 ml at this constant pressure. Determine ΔH and ΔE in joules.

4. Water is boiled under a pressure of 1.0 atm. When an electric current of 0.50 amp from a 12 V supply is passed for 300 s through a resistance in thermal contact with it, it is found that 0.8 gm of water is vapourised. Determine the ΔE in kJ/mol in nearest possible integers at the boiling point of water. Given: $R = 8.314$ JK^{-1} mol^{-1}.

Single Correct Answer Type

5. Difference between ΔH and ΔU for the combustion of benzene at 300 K is
   (a) 7.48 kJ (b) 3.74 kJ
   (c) 14.86 kJ (d) 5.73 kJ

6. The standard enthalpies of formation at 300 K for $CCl_4(l)$, $H_2O(g)$, $CO_2(g)$ and HCl (g) are -107, -242, -394 and -93 kJ mol^{-} respectively. The value of ΔU^{o}_{300} for the reaction
   $CCl_4(l) + 2H_2O(g) \rightarrow CO_2(g) + 4HCl(g)$ is
   (a) -170 kJ mol^{-} (b) -175 kJ mol^{-}
   (c) -182.5 kJ mol^{-} (d) -282.5 kJ mol^{-}

Multiple Correct Answers Type

7. Which of the following reactions have same heat of reaction at constant temperature and at constant volume?
   (a) $H_2(g) + Cl_2(g) \rightleftharpoons 2HCl(g)$
   (b) $2NO(g) \rightleftharpoons N_2(g) + O_2(g)$
   (c) $Co_3O_4(s) + 4CO(g) \rightleftharpoons 3Co(s) + 4CO_2(g)$
   (d) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

8. The heat evolved during the combustion of 46 g ethanol in a bomb calorimeter was determined to be 670.48 kcal mol^{-1} at 25°C. The value of ΔU of the reaction at the same temperature is
   (a) -335.24 kcal (b) -669.28 kcal
   (c) -670.48 kcal (d) -280.26×10^4 J

9. Which of the following is/are correct
   (a) $\Delta H = \Delta U + \Delta(PV)$ when P and V both changes
   (b) $\Delta H = \Delta U + P\Delta V$ when pressure is constant.
   (c) $\Delta H = \Delta U + V\Delta P$ when volume is constant.
   (d) $\Delta H = \Delta U + P\Delta V + V\Delta P$ when P and V both changes

10. For which of the following reaction(s) will ΔH and ΔE are equal?
   (a) $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$
   (b) $H_2(g) + I_2(g) \rightarrow 2HI(g)$
   (c) $C(s) + O_2(g) \rightarrow CO_2(g)$
   (d) $\frac{1}{2}N_2(g) + \frac{3}{2}H_2(g) \rightarrow NH_3(g)$

Matching Column Type

11. Match the following

	Column I		Column II
(a)	Endothermic reaction	(p)	$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$
(b)	Exothermic reaction	(q)	$NH_3(g) \rightarrow N(g) + 3H(g)$
(c)	$\lvert\Delta H\rvert = \lvert\Delta U\rvert$	(r)	$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$
(d)	$\lvert\Delta H\rvert \neq \lvert\Delta U\rvert$	(s)	$\frac{1}{2}H_2(g) + \frac{1}{2}Cl_2(g) \rightarrow HCl(g)$

Integer Type

12. If for a particular reaction, the difference in the heat evolved when the reaction is carried out at constant pressure and that at constant volume at 27°C is nearly 5 kJ mol^{-1}, then

the difference in the number of moles of gaseous reactants and products is …… .

13. For the reaction,

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

Heat of reaction at constant volume exceeds the heat of reaction at constant pressure by the value of xRT. The value of x is ______ .

Comprehension Type

Passage 1:

An ideal gas is taken through a cyclic process through four steps. The heats involved in these steps are $q_1 = 5960$ J, $q_2 = -5585$ J, $q_3 = -2980$ J and $q_4 = 3645$ J, respectively. The corresponding work involved as $w_1 = -2200$ J, $w_2 = +825$ J, $w_3 = +1100$ J and w_4, respectively. Based on these information, answer the following three questions.

14. The work involved in the fourth step is
(a) 765 J (b) –765 J (c) 456 J (d) –456 J

15. The net energy change in the entire process is
(a) 1678 J (b) 2756 J (c) zero (d) –2345 J

16. Which of the following steps is accompanied with a net decrease in the internal energy?
(a) ($1^{st} + 2^{nd}$) steps (b) ($1^{st} + 3^{rd}$) steps
(c) ($3^{rd} + 4^{th}$) steps (d) ($1^{st} + 4^{th}$) steps

Passage 2:

When 12.0 g of carbon reacted with oxygen to form a mixture of CO and CO_2 at 25°C and constant pressure, 315 kJ of heat was released. Given $\Delta_f H°$ (CO, g) = –110 kJ mol^{-1} and $\Delta_f H°$ (CO_2, g) = –395 kJ mol^{-1}. Based on this data, answer the following three questions.

17. Mass of carbon yielding CO is
(a) 6.0 g (b) 9.0 g (c) 21.0 g (d) 23.0 g

18. Mass of oxygen reacted with carbon yielding carbon dioxide is
(a) 15.0 g (b) 19.0 g (c) 21.0 g (d) 23.0 g

19. Mass of total oxygen reacted is
(a) 27.5 g (b) 29.9 g (c) 32 g (d) 35.2 g

Answers Key

Subjective Type

1. 209.72 J mol^{-1}
2. –156.71 kJ
3. 990 J
4. 34.4 kJ/mole

Single Correct Answer Type

5. (b)
6. (b)

Multiple Correct Answers Type

7. (a, b, c)
8. (b, d)
9. (a, b, c)
10. (b, c)

Matching Column Type

11. (a → q), (b → p, r, s), (c → s), (d → p, q, r)

Integer Type

12. 2.0
13. $2RT$

Comprehension Type

14. (b) **15.** (c) **16.** (a) **17.** (b) **18.** (d)
19. (a)

DPP 5.3

Various Types of Enthalpies and Hess's Law

Subjective Type

1. Standard heat of combustion of C_2H_2 (g) and C_2H_4 (g) are –310.6 kcal and –337.2 kcal per mole respectively. Heat of formation of water is –68.3 kcal mol^{-1}. Calculate heat of hydrogenation of C_2H_2 (g) to C_2H_4 (g).
2. Calculate the enthalpy of polymerisation of acetylene to benzene from the following data:
   (i) $C_6H_6\,(l) + 15/2O_2\,(g) \rightarrow 6CO_2\,(g) + 3H_2O(g)$;
   $\Delta H = -3344.48$ kJ
   (ii) $C_2H_2\,(g) + 5/2O_2\,(g) \rightarrow 2CO_2\,(g) + H_2O(g)$;
   $\Delta H = -1297.25$ kJ
3. Use the following data to calculate the enthalpy of formation of As_2O_3.
   (i) $As_2O_3(s) + 3H_2O\,(aq) \rightarrow 2H_3AsO_3(aq)$;
   $\Delta H = +7550$ cal (i)
   (ii) $As(s) + \frac{3}{2}Cl_2(g) \rightarrow AsCl\,(l)$;
   $\Delta H = -71390$ cal (ii)
   (iii) $AsCl_3(l) + (3H_2O + aq) \rightarrow H_3AsO_3(aq) + 3HCl(aq)$;
   $\Delta H = -17580$ cal (iii)
   (iv) $HCl(g) + aq \rightarrow HCl\,(aq)$; $\Delta H = -17315$ cal (iv)
   (v) $\frac{1}{2}H_2(g) + \frac{1}{2}Cl_2(g) \rightarrow HCl(g)$;
   $\Delta H = -22000$ cal (v)
   (vi) $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$;
   $\Delta H = -68360$ cal (vi)
4. A person takes 20 breaths /min. The amount of air inhaled per breath is 500 ml. The inhaled air contains 5% by volume of oxygen. If enthalpy of combustion of sugar is –3690 J/mol and all the oxygen taken in is used for combustion of sugar ($C_{12}H_{22}O_{11}$), find out amount of heat energy liberated (in kJ) per day by combustion of sugar. (Air is inhaled at 1 atm and 27°C)
5. An intimate mixture of ferric oxide, Fe_2O_3 and aluminium, is used in solid fuel of rockets. Determine the fuel value in joules per gm and in joules fuel per cm^3 of the mixture. Given:
   $\Delta_f H\,(Al_2O_3,\,s) = -1669$ kJ/mol
   $\Delta_f H\,(Fe_2O_3,\,s) = -833$ kJ/mol
   Density of $Fe_2O_3 = 5.2\ gm/cm^3$
   Density of $Al = 2.7\ gm/cm^3$

Single Correct Answer Type

6. When a certain amount of ethylene was combusted, 6226 kJ heat was evolved. If heat of combustion of 1 mole of ethylene is 1411 kJ, the volume of O_2 (at NTP) that entered into the reaction is
   (a) 296.5 mL
   (b) 296.5 litres
   (c) 6226 × 22.4 litres
   (d) 22.4 litres
7. $H_2 + 1/2O_2 \rightarrow H_2O$; $\Delta H = -68.39$ kcal
   $K + H_2O \rightarrow KOH(aq.) + \frac{1}{2}H_2$; $\Delta H = -48$ kcal
   $KOH + water \rightarrow KOH\,(aq.)$; $\Delta H = -14$ kcal
   The heat of formation of KOH (in kcal) is
   (a) –68.39 + 48 – 14
   (b) –68.39 – 48 + 14
   (c) 68.39 – 48 + 14
   (d) 68.39 + 48 + 14
8. The heat of neutralisation of a strong acid and a strong alkali is –57.0 kJ mol^{-1}. The heat released when 0.5 mole of HNO_3 solution is mixed with 0.2 mole of KOH is
   (a) –57.0 kJ
   (b) –11.4 kJ
   (c) –28.5 kJ
   (d) –34.9 kJ
9. One mole of soda ash dissolves in water with evolution of 25 kJ of heat. Dissolution of 1 mol of the hydrate crystals in water resulted in the absorption of 67 kJ of heat. The heat released due to hydration of soda ash is
   (a) +92 kJ
   (b) +42 kJ
   (c) –42 kJ
   (d) –92 kJ
10. The heat of formation of $C_2H_5OH(l)$ is –66 kcal/mole. The heat of combustion of $CH_3OCH_3(g)$ is –348 kcal/mole. ΔH_f for H_2O and CO_2 are –68 kcal/mole and –94 kcal/mole respectively. Then, the ΔH for the isomerisation reaction $C_2H_5OH\,(l) \rightarrow CH_3OCH_3(g)$, and ΔE for the same are
    (a) $\Delta = 18$ kcal/mole, $\Delta E = 17.301$ kcal/mole
    (b) $\Delta H = 22$ kcal/mole, $\Delta E = 21.408$ kcal/mole
    (c) $\Delta H = 26$ kcal/mole, $\Delta E = 25.709$ kcal/mole
    (d) $\Delta H = 30$ kcal/mole, $\Delta E = 28.522$ kcal/mole
11. The enthalpy of neutralisation of a weak acid in 1 M solution with a strong base is –56.1 kJ mol^{-1}. If the enthalpy of ionization of the acid is 1.5 kJ mol^{-1} and enthalpy of neutralization of the strong acid with a strong base is

–57.3 kJ equiv^{-1}, what is the % ionization of the weak acid in molar solution (assume the acid to be monobasic)?

(a) 10 (b) 15 (c) 20 (d) 25

Multiple Correct Answers Type

12. Which of the following statements is/are correct?

(a) Enthalpy of combustion of most species is an exothermic process.

(b) Amongst cyclopropane, cyclobutane and cyclopentane, the enthalpy of combustion per CH_2 group is maximum for cyclopropane.

(c) The enthalpy of formation of acetylene is positive

(d) The entropy of all substances at 25°C is positive.

13. Which of the following statements are correct?

(a) The heat released when the requisite amounts of ions in the gaseous state combine to given 1 mol of crystal lattice is known as lattice energy.

(b) Enthalpy of fusion of KCl is larger than that of naphthalene.

(c) The stable state of aggregation of carbon at 298 K and 1 bar pressure is diamond.

(d) The stable state of aggregation of sulphur at 298 K and 1 bar pressure is rhombic sulphur.

14. Which of the following mixtures on neutralization will show a same rise in temperature?

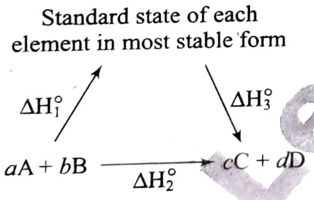
(a) 60 mL of 0.1 M HCl + 60 mL of 0.1 M NaOH

(b) 30 mL of 0.1 M HCl + 30 mL of 0.1 M NaOH

(c) 40 mL of 0.1 M HCl + 30 mL of 0.1 M NaOH

(d) 60 mL of 0.1 M HCl + 100 mL of 0.1 M NaOH

15. Which of the following are incorrect?



(a) $\Delta H_1^\circ = -aH_A^\circ - bH_B^\circ$

(b) $\Delta H_2^\circ = cH_C^\circ + dH_D^\circ$

(c) $\Delta H_3^\circ = cH_C^\circ + dH_D^\circ - aH_A^\circ - bH_B^\circ$

(d) $\Delta H_3^\circ = \Delta H_2^\circ - \Delta H_1^\circ$

16. Which of the following reactions are exothermic?

(a) Rusting of iron (b) Burning of wax

(c) Synthesis of NH_3 (d) Condensation of steam

17. Select the correct statements:

(a) A good fuel has higher calorific value

(b) Endothermic reactions always becomes faster as we approach absolute zero

(c) Enthalpy of vaporization increases from F_2 to I_2

(d) Bond enthalpy of X – X bond has the order:
$F-F > Cl-Cl > Br-Br > I-I$

Matching Column Type

18. Match the following

Column I		Column II	
(a)	$CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$	(p)	Standard enthalpy of formation of CO_2
(b)	$C(graphite) + O_2(g) \rightarrow CO_2(g)$	(q)	Enthalpy of reaction
(c)	$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$	(r)	Enthalpy of combustion of CO(g)
(d)	$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$	(s)	Standard enthalpy of formation of $H_2O(l)$

Integer Type

19. The enthalpy of neutralization of 0.4 M H_2SO_4 will be how many times the enthalpy of neutralization of 0.1 M HCl

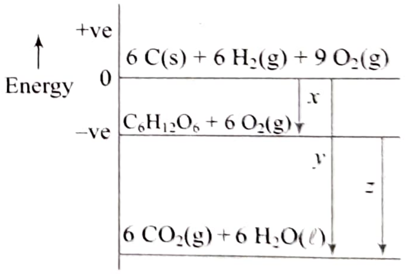
20. The ΔH_f° of $BaSO_4(s)$, $Ba^{2+}(aq)$ and $SO_4^{2-}(aq)$ are –350.6, –128.3 and –216.3 kcal. The heat of reaction (i kcal) is minus:

$BaCl_2(aq.) + H_2SO_4(aq.) \longrightarrow BaSO_4(s) + 2HCl(aq.)$ i

....

Comprehension Type

The energy level diagram for the formation and combustion o glucose is as mentioned.



21. The heat of formation of glucose is

(a) $-x$ (b) $-y$

(c) $x - y$ (d) $-x + z$

22. In the given diagram, z refers to

(a) 6 → (enthalpy of formation of CO_2)

(b) enthalpy of formation of $C_6H_{12}O_6$

(c) enthalpy of combustion of $C_6H_{12}O_6$

(d) enthalpy of combustion of C(s) + enthalpy of formation of $H_2O(l)$

23. The quantity y is equal to
(a) enthalpy of combustion of C(s) + enthalpy of combustion of $H_2(g)$
(b) $x + z$
(c) $x - z$
(d) enthalpy of formation of CO_2 + enthalpy of formation of H_2O

24. Select the incorrect statement(s) from the following:
(a) Combustion of glucose is an endothermic process
(b) Standard state of glucose is $C_6H_{12}O_6(s)$
(c) Heat of formation of glucose = Heat of combustion of glucose
(d) All of the above are incorrect

Answers Key

Subjective Type

1. -41.7 kcal mol^{-1}
2. -547.2 kJ mol^{-1}
3. -154.68 kcal
4. 9 kJ
5. 16470 joules

Single Correct Answer Type

6. (b) **7.** (b) **8.** (b) **9.** (d) **10.** (b)
11. (c)

Multiple Correct Answers Type

12. (a, c, d) **13.** (a, b, d)
14. (a, b) **15.** (b, c)
16. (a, b, c, d) **17.** (a, c)

Matching Column Type

18. (a → r, q), (b → p, q), (c → s, q), (d → q)

Integer Type

19. (8) **20.** (6)

Comprehension Type

21. (a) **22.** (c) **23.** (b) **24.** (d)

DPP 5.4

Concept of Bond Enthalpy in Thermochemical Reactions

Subjective Type

1. Using the data (all values are in kilocalories per mole at 25°C) given below, calculate the bond energy of C–C and C–H bonds.

   ΔH° combustion (ethane) = –372.0
   ΔH° combustion (propane) = –530.0
   ΔH° for C (graphite) → C (g) = 172.0
   Bond energy of H–H = 104.0
   $\Delta_f H^\circ$ of H_2O (*l*) = –68.0
   $\Delta_f H^\circ$ for CO_2(g) = –94.0

2. What is the S – S bond energy if ΔH_f° $(E_t - S - E_t) = -147$ kJ/mol; ΔH_f° $(E_t - S - S - E_t) = -202$ kJ/mol and ΔH_f° S(g) = +233 kJ/mol?

3. Bond energies of F_2 and Cl_2 are 153.0 and 2424 kJ mol^{-1} respectively. The heat liberated in the reaction is 111.0 kJ. Find out the bond energy of F–Cl.

   $1/2F_2 + 1/2Cl_2 \rightarrow FCl$

4. Calculate the resonance energy of N_2O from the following data:

   ΔH°_f of N_2O = 82 kJ mol^{-1},
   N ≡ N 946 kJ mol^{-1};
   N=N, 418 kJ mol^{-1};
   O=O, 498 kJ mol^{-1};
   N=O, 607 kJ mol^{-1}

Single Correct Answer Type

5. The enthalpy of combustion of H_2(g) at 298 K to give H_2O(g) is –249 kJ mol^{-1} and bond enthalpies of H–H and O–O are 433 kJ mol^{-} and 492 kJ mol^{-1}, respectively. The bond enthalpy of O–H is

   (a) 464 kJ mol^{-1} (b) –464 kJ mol^{-1}
   (c) 232 kJ mol^{-1} (d) –232 kJ mol^{-1}

6. Calculate ΔH_r° for the reaction $CH_2Cl_2(g) \rightarrow C(g) + 2H(g) + 2Cl(g)$. The average bond enthalpies of C–H and C–Cl bonds are 414 kJ mol^{-1} and 330 kJ mol^{-1}.

   (a) 1488 kJ mol^{-1} (b) 1468 kJ mol^{-1}
   (c) 1478 kJ mol^{-1} (d) 1498 kJ mol^{-1}

7. The average O–H bond energy in H_2O with the help of following data is:

   (1) H_2O (*l*) → H_2O(g); ΔH = +40.6 kJ mol^{-1}
   (2) 2H(g) → H_2(g); ΔH = –435.0 kJ mol^{-1}
   (3) O_2(g) → 2O(g); ΔH = +489.6 kJ mol^{-1}
   (4) $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$; ΔH = –571.6 kJ mol^{-1}

   (a) 584.8 kJ mol^{-1} (b) 279.8 kJ mol^{-1}
   (c) 462.8 kJ mol^{-1} (d) 925 kJ mol^{-1}

8. Heat of hydrogenation of ethane is x_1 and that of benzen is x_2. Hence, resonance energy is:

   (a) $x_1 - x_2$ (b) $x_1 + x_2$
   (c) $3x_1 - x_2$ (d) $x_1 - 3x_2$

9. Using the data (all values in kJ mol^{-1} at 25°C) given belo

   (A) Entropy of polymerization of ethylene = –72 (kJ pe mole of ethylene)
   (B) Enthalpy of formation of benzene (*l*) = 49 kJ/mole
   (C) Enthalpy of vaporization of benzene (*l*) = 144 kJ mo
   (D) Resonance energy of benzene = –152 kJ/mole
   (E) Heat of formation of gaseous atoms from elements i their standard states H = 436, C = 715.
   (F) Average bond energy of C – H = 415, the bond energ of C – C and C = C are respectively

   (a) 331 kJ/mole and 590 kJ/mole
   (b) 590 kJ/mole and 331 kJ/mole
   (c) 430 kJ/mole and 520 kJ/mole
   (d) 520 kJ/mole and 430 kJ/mole

10. The average Xe – F bond energy is 34 kcal/mol, first I of Xe is 279 kcal/mol, electron affinity of F is 85 kcal/m and bond dissociation energy of F_2 is 38 kcal/mol. The the enthalpy change for the reaction

    $XeF_4 \rightarrow Xe^- + F^- + F_2^+$ will be

    (a) 367 kcal/mole (b) 425 kcal/mole
    (c) 292 kcal/mole (d) 392 kcal/mole

Multiple Correct Answers Type

11. If $\Delta H_f^\circ(C_2H_6)g = -85$ kJ mol^{-1},

    $\Delta H_f^\circ(C_3H_8)g = -104$ kJ mol^{-1}, ΔH° for $C_{(s)} \rightarrow C_{(g)}$ i 718 kJ mol^{-1} and heat of formation of H-atom i 218 kJ mol^{-1}, then:

    (a) $e_{C-C} = 345$ kJ (b) $e_{C-H} = 414$ kJ
    (c) $e_{H-H} = 436$ kJ (d) $e_{H-H} = 218$ kJ

12. Enthalpy of atomisation of C_2H_6 (g) and C_3H_8 (g) are 6 kJ/mol and 880 kJ/mol. Therefore

    (a) D_{C-H} is 90 kJ/mol
    (b) D_{C-C} is 80 kJ/mol

(c) $D_{C=C}$ is 160 kJ/mol
(d) Enthalpy of atomisation of CH_4 is approximately 360 kJ/mol.

Matching Column Type

13. Match the column:

	Column I		Column II
A.	$H_2 \rightarrow 2H$	a.	$\Delta H = \Delta_f H$ of $H \times 2$
B.	$CH_4 \rightarrow C + 4H$	b.	ΔH = Average bond energy × 4
C.	C. $C_2H_2 + 2H_2 \rightarrow C_2H_6$	c.	$\Delta H = e_{C\equiv C} - 4e_{C-H} + 2e_{C-C}$
D.	D. $C_2H_4 + H_2 \rightarrow C_2H_6$	d.	$\Delta H = -e_{C=C} - e_{H-H} + e_{C-H} + e_{C-C}$

Integer Type

14. AB, A_2 and B_2 are diatomic molecules. If the bond enthalpies of A_2, AB and B_2 are in the ratio 1:1:0.5 and enthalpy of formation of AB from A_2 and B_2 is –100 kJ/mole^{-1}. The bond enthalpy of A_2 is $x \times 10^2$ KJ mol^{-1} what is x.

Answers Key

Subjective Type

1. 99 kcal mol^{-1}, 99 kcal mol^{-1}
2. 278 kJ
3. +1177.5 kJ mol^{-1} **4.** –88 kJ mol^{-1}

Single Correct Answer Type

5. (a) **6.** (a) **7.** (c) **8.** (c)
9. (a) **10.** (c)

Multiple Correct Answers Type

11. (a, b, c) **12.** (a, b, d)

Matching Column Type

13. (A→a), (B→b), (C→c), (D→d)

Integer Type

14. 400 kJ/mol

DPP 5.5

Entropy, Gibb's Energy and Spontaneity of Process

Subjective Type

1. Calculate the equilibrium constant, K for the following reaction at 400 K?

$$2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$$

Given that $\Delta_r H^o = 80.0$ kJ mol^{-1} and $\Delta_r S^o = 120$ JK^{-1} mol$^-$ at 400 K.

2. Sodium carbonate (Na_2CO_3) can be obtained by heating sodium hydrogen carbonate, $NaHCO_3$.

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$$

Calculate the temperature above which $NaHCO_3$ decomposes to form products at 1 bar.

Given $\Delta_f H^o$ (kJ mol^{-1}) :

$NaHCO_3$ (s) = –947.7, Na_2CO_3(s) = –1130.9, H_2O(g) = –241.8, CO_2(g) = –393.5

S^o (JK^{-1} mol^{-1}) : $NaHCO_3$(s) = 102.1 Na_2CO_3(s) = 136.0, H_2O(g) = 188.8, CO_2(g) = 213.7

3. $2Zn + O_2 \rightarrow 2ZnO$; $\Delta G^o = -161$ J (i)

$2Zn + S \rightarrow 2ZnS$; $\Delta G^o = -293$ J (ii)

$2S + 2O_2 \rightarrow 2SO_2(g)$; $\Delta G^o = -408$ J (iii)

What would be ΔG^o for the following reaction?

$$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$$

4. The equilibrium constant for the reaction given below is 2.0×10^{-7} at 300 K. Calculate the standard free energy change for the reaction:

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

Also, calculate the standard entropy change if $\Delta H^\circ = 28.40$ kJ mol^{-1}.

5. Two moles of an ideal gas is expanded isothermally and irreversibly at 27°C from volume V_1 to 2.5 V_1 and 4.17 kJ heat is absorbed from surroundings. Determine ΔS_{sys}, ΔS_{surr} and ΔS_{univ}.

6. An ideal monoatomic gas was at 1 atm and 300 K. If one mole of such ideal gas is allowed to expand adiabatically against a constant pressure of 0.3 atm till double its volume, determine $\Delta S \times 10^3$ in JK^{-1} mol^{-1} for the process in the nearest possible integers.

Given: log 2 = 0.3; log 3 = 0.48; log 5 = 0.7

Single Correct Answer Type

7. The enthalpy of vaporization of water at 100°C is 40.63 kJ mol^{-1}. Its entropy of vaporization would be
   - (a) 406.3 JK^{-1} mol^{-1}
   - (b) 108.9 JK^{-1} mol^{-1}
   - (c) 606.3 JK^{-1} mol^{-1}
   - (d) 4063 kJ mol^{-1}

8. For a reaction $A(g) \rightleftharpoons B(g)$ at equilibrium, the partial pressure of B is found to be one-fourth of the particle pressure of A. The value of ΔG^o of the reaction A → B is
   - (a) RT ln 4
   - (b) $-RT$ ln 4
   - (c) RT log 4
   - (d) $-RT$ log 4

9. The value of $\log_{10}$ K for a reaction $A \rightleftharpoons B$ is

(Given: $\Delta_r H_{298\ K} = -54.07$ kJ mol^{-1}, $\Delta_r S^o_{298\ K}$ = 10 J K^{-1} mol^{-1} and $R = 8.314$ JK^{-1} mol^{-1}; $2.303 \times 8.314 \times 298 = 5705$).
   - (a) 5
   - (b) 10
   - (c) 95
   - (d) 100

10. For the reaction, $2O_3 \rightarrow 3O_2$, ΔH, ΔS and ΔG are respectively:
    - (a) +ve, + ve, +ve
    - (b) –ve, + ve, –ve
    - (c) –ve, –ve, +ve
    - (d) +ve, –ve, –ve

11. Predict which of the following reaction(s) has a positive entropy change?

    (I) $Ag^+ (aq) + Cl^-(aq) \rightarrow AgCl(s)$

    (II) $NH_4Cl(s) \rightarrow NH_3(g) + HCl(g)$

    (III) $2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$
    - (a) I and II
    - (b) III
    - (c) II and III
    - (d) II

12. When two mole of an ideal gas $\left(C_{p,m} = \frac{5}{2}R\right)$ heated from 300 K to 600 K at constant pressure. The change in entropy of gas (ΔS) is:
    - (a) $\frac{3}{2}R \ln 2$
    - (b) $-\frac{3}{2}R \ln 2$
    - (c) $5R \ln 2$
    - (d) $\frac{5}{2}R \ln 2$

13. For the reaction:

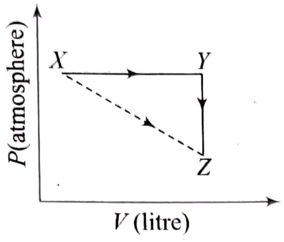
$$A\ (g,\ 1\ bar) + 1/2B_2\ (g,\ 25\ bar) \rightleftharpoons AB(g)$$

What is the initial free energy change?
    - (a) $\Delta G = +\infty$
    - (b) $\Delta G = 0$
    - (c) $\Delta G = -\infty$
    - (d) ΔG = cannot be determined

Cengage Learning Ltd

Multiple Correct Answers Type

14. For an ideal gas, consider only P-V work in going from an initial state X to the final state Z. The final state Z can be reached by either of the two paths shown in the figure. Which of the following choice(s) is(are) correct? [Take ΔS as change in entropy and w as work done].



(a) $\Delta S_{x\to z} = \Delta S_{x\to y} + \Delta S_{y\to z}$
(b) $w_{x\to z} = w_{x\to y} + w_{y\to z}$
(c) $w_{x\to y\to z} = w_{x\to y}$
(d) $\Delta S_{x\to y\to z} = \Delta S_{x\to y}$

15. A reaction attains equilibrium state under standard conditions, then:
(a) equilibrium constant $K = 0$
(b) equilibrium constant $K = 1$
(c) $\Delta G^\circ = 0$ and $\Delta H^\circ = T\Delta S^\circ$
(d) $\Delta G = 0$ and $\Delta H = T\Delta S$

16. Select the correct statement for the equilibrium under standard conditions:

$H_2O(s) \rightleftharpoons H_2O(l);\ \Delta S_1^o$
$H_2O(l) \rightleftharpoons H_2O(v);\ \Delta S_2^o$
$H_2O(s) \rightleftharpoons H_2O(v);\ \Delta S_3^o$

(a) $\Delta S_1^o > \Delta S_2^o$ (b) $\Delta S_2^o >>> \Delta S_1^o$
(c) $\Delta S_3^o > \Delta S_2^o$ (d) $\Delta S_3^o > \Delta S_1^o$

17. Select the correct expression among the following:

(a) $\dfrac{\Delta G - \Delta H}{T} = \left(\dfrac{\partial \Delta G}{\partial T}\right)_P$ (b) $\dfrac{\Delta G - \Delta H}{T} = \left(\dfrac{\partial (\Delta G)}{\partial T}\right)_V$

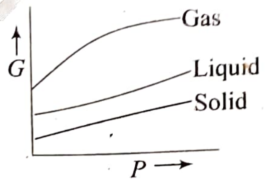
(c) $\dfrac{\Delta S}{nF} = \left(\dfrac{\partial E_{cell}}{\partial T}\right)_P$ (d) $\left(\dfrac{\partial H}{\partial P}\right)_H = -\left(\dfrac{\partial H}{\partial P}\right)_{T/C_P}$

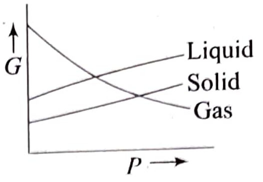
18. In which of the following process entropy increases?
(a) Rusting of iron
(b) Vaporizations of Camphor
(c) Crystallisation of sugar from syrup
(d) Atomizations of dihydrogen

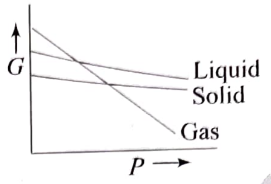
19. In which of the following reaction $\Delta_r S^\circ > 0$.

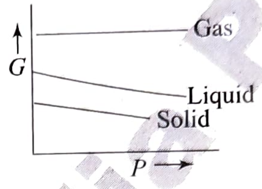
(a) $O_2(g) + \frac{1}{2}O_2(g) \rightarrow SO_3(g)$
(b) $2O_3(g) \rightarrow 3O_2(g)$
(c) $NaCl(s) \rightarrow NaCl(aq)$
(d) $H_2(g) \rightarrow 2H(g)$

20. Which of the following correctly represent the variation of G?

(a)


(b)


(c)


(d)


Matching Column Type

21. Match the process in Column I with their properties in Column II.

	Column I		Column II
A.	$H_2O(l) \rightleftharpoons H_2O(g)$	1.	$\Delta G < 0$
B.	$C(s) + O_2(g) \rightarrow CO_2(g)$	2.	$\Delta H > 0$
C.	$H_2O(s) \rightleftharpoons H_2O(l)$	3.	$\Delta S > 0$
D.	$C(s) + \frac{1}{2}O_2(g) \rightarrow CO(g)$	4.	$\Delta H < 0$

Integer Type

22. At 0°C, if enthalpy of fusion of ice is 1365 kcal/mol. The molar entropy change for melting of ice at 0°C is ..... kcal.

23. 64 grams of methanol at a temperature of 60°C are poured into 128 grams of methanol kept at 20°C in an insulated vessel. Calculate the net change in entropy that occurs. (Give your answer in J/K and in the form of nearest whole number)
[$\log(0.9198) = -0.036$; $\log(1.045) = 0.0193$]

Comprehension Type

Passage 1:

The second law of thermodynamics is a fundamental law of science. In this problem we consider the thermodynamics of an ideal gas, phase transition and chemical equilibrium.

5 moles of CO_2 gas expand isothermally (in thermal contact with surrounding temperature = 15°C) against a fixed external pressure of 1.00 bar. The initial and final volume of gas are 10.0 L and 30.0 L respectively

24. Assuming CO_2 to be an ideal gas ΔS_{system} is:
(a) 27.4 J/K/mol (b) 9.1 J/K/mol
(c) −27.4 J/K/mol (d) −9.15 J/K/mol

25. If expansion of gas takes place reversibly, then ΔS_{system} would have been
(a) 19.82 J/K (b) 45.66 J/K
(c) 84.21 J/K (d) 9.1 J/K

26. $\Delta S_{surrounding}$ is
(a) −27.4 J/K (b) 6.94 J/K
(c) 0.00 J/K (d) −6.94 J/K

Passage 2:

G, H, A, U and S are all state functions and they are defined as follows:

$$G = H - TS; \quad H = U + PV; \quad A = U - TS$$
$$dq = TdS \quad \text{and } dU = dq - PdV$$

27. Which of the following relation(s) is/are correct?

(a) $\left(\frac{\partial G}{\partial T}\right)_P = -S$

(b) $\left(\frac{\partial G}{\partial P}\right)_T = V$

(c) Both (a) and (b) are correct

(d) Neither (a) nor (b) is correct

28. Which of the following relation (s) is/are correct?

(a) $\left(\frac{\partial V}{\partial T}\right)_P = -\left(\frac{\partial S}{\partial P}\right)_T$

(b) $\left(\frac{\partial V}{\partial T}\right)_P = \left(\frac{\partial S}{\partial P}\right)_T$

(c) $\left(\frac{\partial V}{\partial S}\right)_P = -\left(\frac{\partial T}{\partial P}\right)_T$

(d) Both (a) and (c) are correct.

29. Which of the following relation(s) is/are correct?

(a) $\left(\frac{\partial A}{\partial V}\right)_T = -P$ (b) $\left(\frac{\partial A}{\partial T}\right)_V = -S$

(c) $\left(\frac{\partial P}{\partial T}\right)_V = \left(\frac{\partial S}{\partial V}\right)_T$ (d) All of the given

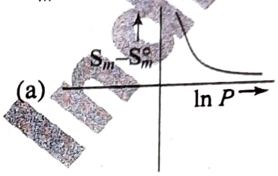
Passage 3:

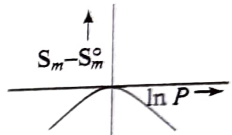
Entropy change of an ideal gas is given by,

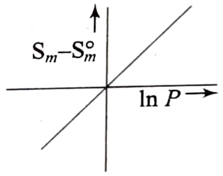
$$\Delta S = n\left[C_v \ln\frac{T_2}{T_1} + R\ln\frac{V_2}{V_1}\right] \text{ or } \Delta S = n\left[C_p \ln\frac{T_2}{T_1} + R\ln\frac{P_1}{P_2}\right]$$

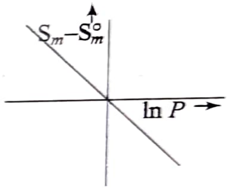
The standard molar entropy of an ideal gas ($S°_m$), is the entropy of 1 mole of an ideal gas at 1 bar pressure and at definite temperature. S_m stands for molar entropy of an ideal gas at pressure P bar.

30. Which of the following figure represent the variation of ($S_m - S°_m$) vs P (in bar)?

(a)


(b)


(c)


(d)


31. One mole of an ideal gas undergoes free expansion until its volume is tripled. What is the entropy change of the universe for the given process?
(a) −*R* ln 2
(b) *R* ln 3
(c) zero
(d) cannot be determined since process is irreversible.

Answers Key

Subjective Type

1. 6.634×10^{-5}
2. 386.5 K
3. −731 J
4. 38.48 kJ, −33.6 J mol^{-1} K^{-1}
5. 15.32 J, −13.9 J, 1.42 J
6. 2.872 J K^{-1} mol^{-1}.

Single Correct Answer Type

7. (b) **8.** (a) **9.** (b) **10.** (b) **11.** (c)
12. (c) **13.** (c)

Multiple Correct Answers Type

14. (a, c) **15.** (b, c, d)
16. (b, c, d) **17.** (a, c, d)
18. (b, d) **19.** (b, c, d)

20. (a, c)

Matching Column Type

21. (A→1, 2, 3), (B→1, 4), (C→1, 2, 3), D→(1, 3, 4)

Integer Type

22. 5 **23.** 1 JK^{-1}

Comprehension Type

24. (b) **25.** (b) **26.** (d) **27.** (c) **28.** (a)
29. (d) **30.** (d) **31.** (b)

DPP 5.6

Heat Capacity and Calorimetry

Subjective Type

1. A 1.250 g sample of octane (C_8H_{18} is burned in excess of oxygen in a bomb calorimeter. The temperature of the calorimeter rises from 294.05 K to 300.78 K. If heat capacity of the calorimeter is 8.93 kJ/K, find the heat transferred to the calorimeter. Also calculate the enthalpy combustion of the sample of octane.
2. Calculate the enthalpy change on freezing 1.0 mol of water at 10.0°C to ice at –10.0°C.

   $\Delta_{fus} H = 6.03$ kJ mol^{-1} at 0°C

   $C_p[H_2O\ (l)] = 75.3$ J mol^{-1} K^{-1}

   $C_p[H_2O(s)] = 36.8$ J mol^{-1} K^{-1}.
3. Calculate ΔU and ΔH in calories if one mole of monoatomic ideal gas is heated at constant pressure of 1 atm from 25°C to 50°C.
4. 3.5 g of a fuel (with molecular weight 28), was burnt in a calorimeter and raised the temperature of 1 g water from 25°C to 67.3°C. If all the heat generated was used in heating water, calculate heat of combustion of fuel.

Single Correct Answer Type

5. A solution of 200 mL of 1 M KOH is added to 200 mL of 1 M HCl and the mixture after attaining reaction equilibrium shows a rise in temperature by ΔT_1. The experiment is repeated by using 50 mL of 1 M KOH and 50 mL 1 M HCl which at equilibrium shows a rise in temperature by ΔT_2. Thus:

   (a) $\Delta T_1 = \Delta T_2$ (b) $\Delta T_1 = 4 \times \Delta T_2$

   (c) $\Delta T_1 = 2 \times \Delta T_2$ (d) $\Delta T_1 > \Delta T_2$
6. Molar heat capacity of water in equilibrium water $\rightleftharpoons$ vapours at constant pressure is:

   (a) zero (b) infinity

   (c) $\frac{80}{18}$ cal/mol (d) $\frac{540}{18}$ cal/mol
7. 4 kg of ice at –20°C is mixed with 10 kg of water at 20°C in an insulating vessel having a negligible heat capacity. Calculate the final mass of water remaining in the container. Given: Specific heat capacities of water and ice are 4.184 kJ K^{-1} kg^{-1} and 2.092 kJ K^{-1}, respectively. Molar enthalpy of fusion of ice is 334.7 kJ kg^{-1}.

   (a) 8 kg (b) 10 kg (c) 12 kg (d) 14 kg
8. Ice–Water mass ratio is maintained as 1 : 1 in a given system containing water in equilibrium with ice at constant pressure. If C_P (ice) = C_P (water) = 4.18 J mol^{-1} K^{-1}, molar heat capacity of such a system is

   (a) Zero (b) Infinity

   (c) 4.182 JK^{-1} mol^{-1} (d) 75.48 JK^{-1} mol^{-1}
9. A piece of zinc at a temperature of 20°C weighing 65.38 g is dropped into 180 g of boiling water (T = 100°C). The specific heat of zinc is 0.4 J g^{-1} C^{-1} and that of water is 4.2 J g^{-1}°C^{-1}. What is the final common temperature reached by both the zinc and water?

   (a) 97.3°C (b) 33.4°C

   (c) 80.1°C (d) 60.0°C
10. In Haber's process of manufacturing of ammonia:

    $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$; $H^o_{25°C} = -92.2$ kJ

Molecule	$N_2(g)$	$H_2(g)$	$NH_3(g)$
C_P JK^{-1} mol^{-1}	29.1	28.8	35.1

    If C_P is independent of temperature, then reaction at 100°C as compared to that of 25°C will be:

    (a) More endothermic (b) Less endothermic

    (c) More exothermic (d) Less exothermic
11. For the hypothetical reaction

    $$A_2(g) + B_2(g) \rightleftharpoons 2AB(g)$$

    If $\Delta_r G°$ and $\Delta_r S°$ are 20 kJ/mol and –20 JK^{-1} mol^{-1} respectively at 200 K.

    $\Delta_r C_p$ is 20 JK^{-1} mol^{-1}, then $\Delta_r H°$ at 400 K is:

    (a) 20 kJ/mol (b) 7.98 kJ/mol

    (c) 28 kJ/mol (d) None of these
12. The heat of formation of HCl at 348 K form the following data, will be

    $0.5\ H_2(g) + 0.5\ Cl_2(g) \rightarrow HCl$; $\Delta H^o_{298} = -22060$ cal

    The mean heat capacities over this temperature range are, $H_2(g)$, $C_P = 6.82$ cal mol^{-1} K^{-1}; $Cl_2(g)$, $C_P = 7.71$ cal mol^{-1} K^{-1}; HCl(g), $C_P = 6.81$ cal mol^{-1} K^{-1}

    (a) –20095 cal (b) –32758 cal

    (c) –37725 cal (d) –22083 cal

Multiple Correct Answers Type

13. Which of the following relationships are correct?

    (a) $\frac{\Delta H - \Delta E}{\Delta n \times T}$ = Constant

    (b) $\Delta G = -T\Delta S_{Total}$

(c) $q = \Delta U + w$ (d) $K = e^{-\Delta G^{\circ}/RT}$

(e) $\left[\frac{\partial(\Delta H)}{\partial T}\right]_P = \Delta C_p$

14. Which of the following statements are correct?

(a) The value of $C_{p,m}/C_{V,m}$ for a mixture of 1 mol of a monoatomic gas ($\gamma = 5/3$) and 1 mol of a diatomic gas ($\gamma = 7/5$) is 1.5.

(b) The work done by an ideal gas in expanding V_1 to V_2 is higher when the expansion is done isothermally as compared to that carried out adiabatically.

(c) The internal energy of an ideal gas does not change in the isothermal process.

(d) The fraction of heat utilized in increasing energy of a monatomic gas is 3/5 when the heat is supplied under constant pressure condition.

15. The Poisson's ratio for O_2 is 1.4. Which are correct for O_2?

(a) $C_v = 5$ cal (b) $C_v = 0.156$ cal

(c) $C_p = \frac{R\gamma}{\gamma - 1}$ (d) $C_v = \frac{R}{(\gamma - 1)}$

Matching Column Type

16. Match the Column I with Column II.

	Column I		Column II
a.	O_2	p.	$\gamma = 1.4$
b.	N_2	q.	$C_P = \frac{7}{2}R$
c.	CO_2, CH_4	r.	$C_P = \frac{23}{6}R$
d.	1 mol O_2 + 2 mol O_3	s.	$\gamma = 1.33$

Integer Type

17. In a constant volume calorimeter, 3.5 g of a gas with molecular weight 28 was burnt in excess oxygen at 298.0 K. The temperature of the calorimeter was found to increase from 298.0 K to 298.45 K due to the combustion process. Given that the heat capacity of the calorimeter is 2.5 kJ K^{-1}, the numerical value for the enthalpy of combustion of the gas kJ mol^{-1} is …… .

18. The molar heat capacity of water at constant pressure is 75 JK^{-1} mol^{-1}. When 0.850 kJ of heat is supplied to 100 g of water which is free to expand, the increase in temperature in K of water is …… .

Comprehension Type

Passage 1:
An ideal gas is taken through a cyclic process of four steps. The heats involved in these steps are $q_1 = 5960$ J, $q_2 = -5585$ J, $q_3 =$ -2980 J and $q_4 = 3645$ J, respectively. The corresponding work involved as $w_1 = -2200$ J, $w_2 = +825$ J, $w_3 = +1100$ J and w_4, respectively. Based on these information, answer the following three questions.

19. The work involved in the fourth step is

(a) 765 J (b) –765 J (c) 456 J (d) –456 J

20. The net energy change in the entire process is

(a) 1678 J (b) 2756 J (c) zero (d) –2345 J

21. Which of the following steps is accompanied with a net decrease in the internal energy?

(a) ($1^{st} + 2^{nd}$) steps (b) ($1^{st} + 3^{rd}$) steps

(c) ($3^{rd} + 4^{th}$) steps (d) ($1^{st} + 4^{th}$) steps

Passage 2:
Enthalpy of sublimation may be determined experimentally but instead of that let us explore an easier route for this datum. Enthalpy changes depends only on the initial and the final states and not on the path. Therefore we must find the same value for and enthalpy change whether the system goes directly from solid to gas or through the intermediate state of a liquid therefore.

$\Delta H_{sub} = \Delta H_{fus} + \Delta H_{vap}$

The above equation is true only when values are measured at the same temperature. But if enthalpy data are given at different temperature, then enthalpy change can be calculated by Kirchhoff's law.

$$\Delta H_2 - \Delta H_1 = (C_{P2} - C_{P1})(T_2 - T_1)$$

If molar heat capacity of

$H_2O(s) = 35.5\ JK^{-1}\ mol^{-1}$
$H_2O\ (l) = 75.5\ JK^{-1}\ mol^{-1}$
$H_2O(g) = 30.5\ JK^{-1}\ mol^{-1}$

Heat of vaporization = 40.66 kJ/mol
Heat of fusion of H_2O = 6.0 kJ/mol

22. Molar enthalpy of vaporization of H_2O at 0°C is

(a) 45.16 kJ/mol (b) 36.16 kJ/mol

(c) –45.16 kJ/mol (d) –36.16 kJ/mol

23. Molar enthalpy of fusion of H_2O at 100°C in kJ/mol

(a) –4.0 (b) 4.0 (c) 10.0 (d) –10.0

24. Molar enthalpy of sublimation of H_2O at 100°C in kJ/mo is:

(a) 36.66 (b) 40.66 (c) 30.66 (d) 50.66

Answers Key

Subjective Type

1. 60.1 kJ, 5481.1 kJ mol^{-1}
2. –7.151 kJ mol^{-1}
3. 124.2 cal, 74.5 cal
4. –338.4 kcal

Single Correct Answer Type

5. (a) **6.** (b) **7.** (c) **8.** (a) **9.** (a)
10. (c) **11.** (a) **12.** (d)

Multiple Correct Answers Type

13. (a, b, d, e) **14.** (a, c)
15. (a, b, c, d)

Matching Column Type

16. (a→p, q), (b→p, q), (c→s), (d→r)

Integer Type

17. (9) **18.** (2)

Comprehension Type

19. (b) **20.** (c) **21.** (a) **22.** (a) **23.** (c)
24. (d)

CHAPTER

6

Chemical Equilibrium

DPP 6.1

Types of Equilibrium, Equilibrium Constant and Law of Mass Action

Subjective Type

1. State which one is homogeneous or heterogeneous?
   - (a) $S_{Rhombus} \rightleftharpoons S_{Monoclinic}$
   - (b) $H_2O\ (l) \rightleftharpoons H_2O\ (v)$
   - (c) $H_2O(s) \rightleftharpoons H_2O(l)$
   - (d) $C_{Diamond} \rightleftharpoons C_{Amorphous}$
   - (e) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
   - (f) $CuSO_4(s) + 3NH_3(l) \rightleftharpoons CuSO_4 \cdot 3NH_3(l)$
   - (g) $CaCO_3(g) \rightleftharpoons CaO(s) + CO_2(g)$
2. Write equilibrium constants for each;
   - (a) $KClO_3(s) \rightleftharpoons KCl(s) + \frac{3}{2}O_2$
   - (b) $H_2(g) + 3Fe_2O_3(s) \rightleftharpoons H_2O(g) + 2Fe_3O_4(s)$
   - (c) $CaC_2(s) + 5O_2(g) \rightleftharpoons 2CaCO_3(s) + 2CO_2(g)$
   - (d) $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$
   - (e) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
   - (f) $CH_3COOH\ (l) + CH_3OH\ (l) \rightleftharpoons CH_3COOCH_3\ (l) + H_2O(l)$
3. At a certain temperature and a total pressure of 10^5 Pa, iodine vapour contains 40% by volume of I atoms.

   $I_2(g) \rightleftharpoons 2I(g)$

   Calculate K_P for the equilibrium.
4. When baking soda is heated in a sealed tube, following equilibrium exists:

   $$2NaHCO_3(s) \rightleftharpoons Na_2CO_3(s) + CO_2(g) + H_2O(g)$$

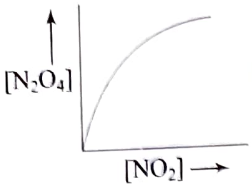
   If the equilibrium pressure is 1.04 atm at 398 K, calculate the equilibrium constant for the reaction at 398 K.

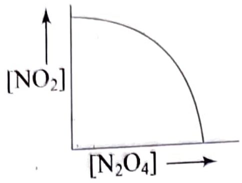
Single Correct Answer Type

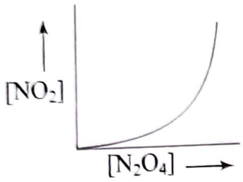
5. Which of the following statements is incorrect?
   - (a) In equilibrium mixture of ice and water kept in perfectly insulated flask, mass of ice and water does not change with time.
   - (b) The intensity of red colour increases when oxalic acid is added to a solution containing iron (III) nitrate and potassium thiocyanate.
   - (c) On addition of catalyst the equilibrium constant value is not affected.
   - (d) Equilibrium constant for a reaction with negative ΔH value decreases as the temperature increases.
6. For an ideal-gas reaction $2A + B \rightleftharpoons C + D$, the value of K_p^o will be:
   - (a) $K_p^o = \frac{n_C n_D}{n_A^2 n_B} \frac{V_P^o}{RT^2}$
   - (b) $K_p^o = \frac{n_C n_D}{n_A^2 n_B} \frac{P^o}{RT}$
   - (c) $K_p^o = \frac{n_C n_D}{n_A^2 n_B} \frac{RT^2}{V_P^o}$
   - (d) $K_p^o = \frac{n_C n_D}{n_A^2 n_B} \frac{V_P^o}{RT}$

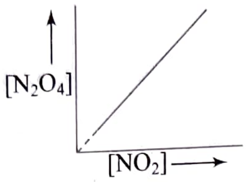
7. The equilibrium constant for the following reaction $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ is $K = \frac{[NO_2]^2}{[N_2O_4]}$

Which of the following graphs is correct?

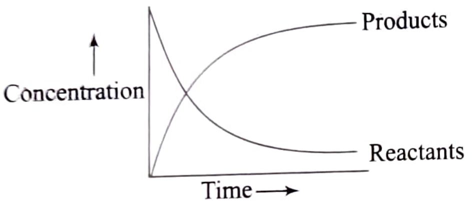
(a)


(b)


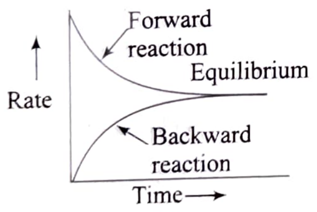
(c)


(d)


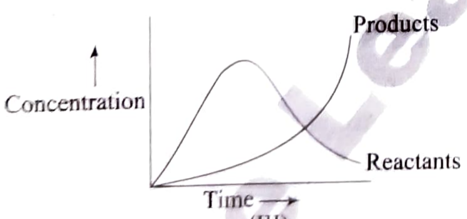
8. In the reaction, $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$. Which of the graph is/are correct?



(I)



(II)

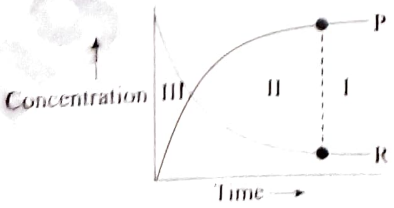


(III)

(a) I, II
(b) I, II, III
(c) II, III
(d) I, III

9. For the reaction $R \rightleftharpoons P$,

Variation of concentration is plotted against time:



Which of the following regions show(s) equilibrium?

(a) III
(b) II
(c) I
(d) both II and III

10. An aquatic species needs at least 4 mg/litre O_2 for their survival. The solubility of O_2 in water at 273 K and 1 atm pressure is 2.21×10^{-3} mol litre^{-1}. The partial pressure of O_2 above water (in atmosphere at 273 K) needed for survival of species is:

(a) 0.56 atm
(b) 5.525×10^{-3} atm
(c) 5.525 atm
(d) 0.056 atm

11. In a reversible reaction $A \rightleftharpoons B$, the initial concentration of A and B are a and b in moles per litre and the equilibrium concentration are $(a - x)$ and $(b + x)$ respectively, express x in terms of k_1, k_2, a and b.

(a) $\frac{k_1 a - k_2 b}{k_1 + k_2}$
(b) $\frac{k_1 a - k_2 b}{k_1 - k_2}$
(c) $\frac{k_1 a - k_2 b}{k_1 k_2}$
(d) $\frac{k_1 a + k_2 b}{k_1 + k_2}$

12. In the system, $LaCl_3(s) + H_2O(g) + \text{heat} \rightleftharpoons LaClO(s) + 2HCl(g)$, equilibrium. More water vapour is added to restablish the equilibrium. The pressure of water vapour is doubled. The factor by which pressure of HCl is changed is:

(a) 2
(b) $\sqrt{2}$
(c) $\sqrt{3}$
(d) $\sqrt{5}$

Multiple Correct Answers Type

13. At a particular temperature and atmospheric pressure, the solid and liquid phases of a pure substance can exist in equilibrium. Which of the following term defines the temperature?

(a) Normal melting point
(b) Equilibrium temperature
(c) Boiling point
(d) Freezing point

14. Select the correct statements:

(a) An increase in pressure increases the boiling point of liquid.
(b) An increase in pressure increases the melting point of water.
(c) On spraying NaCl on ice, the melting point of ice is lowered and it does not melt.
(d) The three phases of a substance exists at triple point only.

15. Which are heterogeneous system?

(a) Ice $\rightleftharpoons$ Water
(b) Water $\rightleftharpoons$ Liquid
(c) $S_{\text{Rhombic}} \rightleftharpoons S_{\text{Monoclinic}}$
(d) $C_{\text{Diamond}} \rightleftharpoons C_{\text{Amorphous}}$

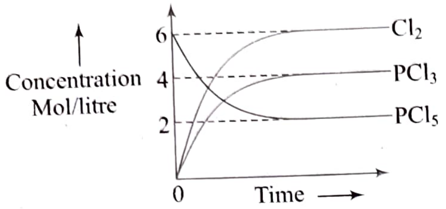
16. Select the correct statements:

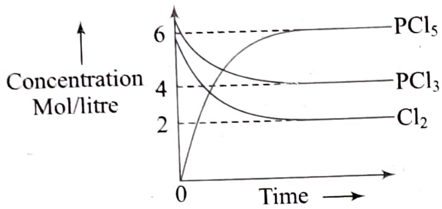
(a) Volume of gas dissolved per unit volume of solvent $\propto (P)^0$ at constant T.
(b) Amount of gas dissolved per unit volume of solvent $\propto$ P at constant T.
(c) Mole fraction of gas dissolved per unit volume of solvent $\propto$ P at constant T.
(d) Henry law is a special case of Nernst distribution law

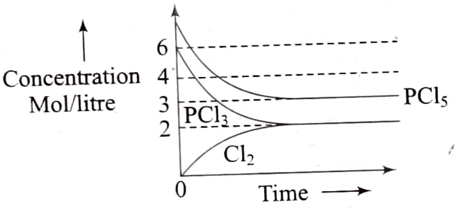
17. For the equilibrium

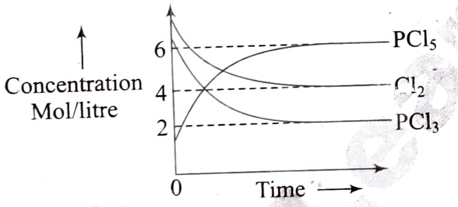
$$PCl_5 \rightleftharpoons PCl_3(g)$$

Which of the following sketch may represent above equilibrium? Assume equilibrium can be achieved from either side and by taking any one or more components initially. (Given K_C for the reaction < 2).

(a)


(b)


(c)


(d)


Matching Column Type

18. Match the Column I with Column II:

Column I (Gaseous reaction)	Column II (Unit of K_p)
a. $H_2(g) + Cl_2(g) \rightleftharpoons 2HCl(g)$	p. atm^{-1}
b. $3O_2(g) \rightleftharpoons 2O_3(g)$	q. unitless
c. $SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g)$	r. $bar^{-1/2}$
d. $CO(g) + 3H_2(g) \rightleftharpoons CH_4(g) + H_2O(g)$	s. atm^{-2}
	t. bar^{-1}

Comprehension Type

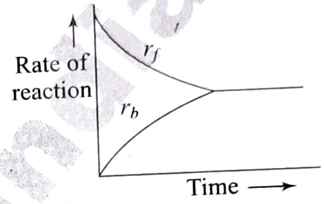
In a reversible chemical reaction, the rate of forward reaction decreases and that of backward reaction increases with the passage of time; at equilibrium the rate of forward and backward reactions become same. Let us consider the formation of $SO_3(g)$ in the following reversible reaction:

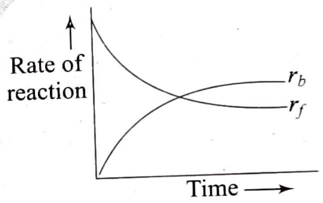
$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

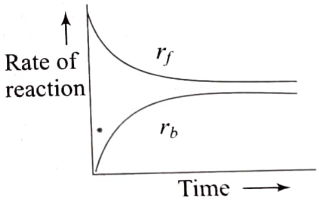
Following graphs are plotted for this reactions:

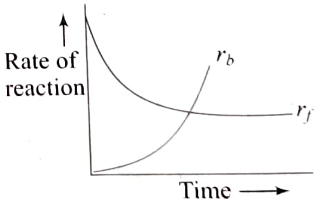
19. In the above graph, A B and C respectively are
   (a) SO_3, SO_2 and O_2 (b) SO_3, O_2 and SO_2
   (c) SO_2, O_2 and SO_3 (d) O_2, SO_2 and SO_3

20. Which of the following represent the rates of forward reaction (r_f) and rates of backward reaction (r_b) at equilibrium?

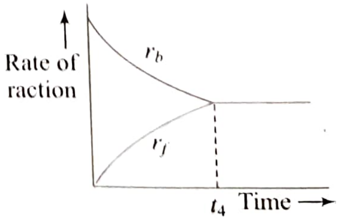
(a)


(b)


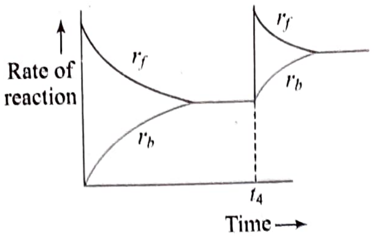
(c)


(d)


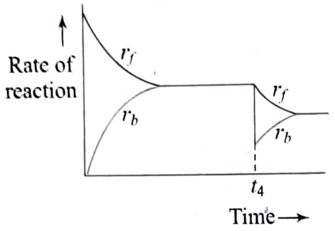
21. The reaction A + B $\rightleftharpoons$ C + D is in equilibrium at time t_4. At t_4 in the equilibrium extra amount of A is added, which of the following correctly represent the changes in rate of reaction?

(a)


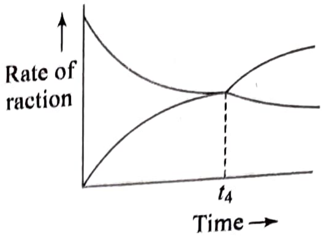
(b)



(c)



(d)



Answers Key

Subjective Type

1. Homogeneous – e, Heterogeneous – a, b, c, d, f, g
3. 2.67×10^4 Pa
4. 0.2704 atm

Single Correct Answer Type

5. (b) **6.** (d) **7.** (b) **8.** (a) **9.** (c)
10. (d) **11.** (a) **12.** (b)

Multiple Correct Answers Type

13. (a, d) **14.** (a, b, d)
15. (a, b, c, d) **16.** (a, b, c, d)
17. (b, d)

Matching Column Type

18. (a→q), (b→p, t), (c→r), (d→s)

Comprehension Type

19. (a) **20.** (a) **21.** (b)

DPP 6.2

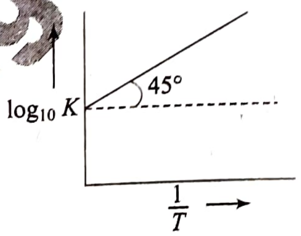
Applications of Equilibrium Constant (*K*)

Subjective Type

1. The equilibrium constant of a reaction doubles on increasing the temperature of the reaction from 25°C to 35°C. Calculate enthalpy change of the reaction, assuming it to be constant in this temperature range.
2. Sulphide ion in alkaline solution reacts with solid sulphur to form polysulphide ions having formula, $S_2^{2-}, S_3^{2-}, S_4^{2-}$, etc. If $K_1 = 12$ for $S + S^{2-} \rightleftharpoons S_2^{2-}$ and $K_2 = 132$ for $2S + S^{2-} \rightleftharpoons S_3^{2-}$, calculate K_3 for $S + S_2^{2-} \rightleftharpoons S_3^{2-}$.
3. Predict which of the following reaction will have appreciable concentration of reactants and products :
   (a) $Cl_2(g) \rightleftharpoons 2Cl(g)$ $K_c = 5 \times 10^{-39}$
   (b) $Cl_2(g) + 2NO(g) \rightleftharpoons 2NOCl(g)$ $K_c = 3.7 \times 10^8$
   (c) $Cl_2(g) + 2NO_2(g) \rightleftharpoons 2NO_2Cl(g)$ $K_c = 1.8$
4. Determine K_C for the reaction
   $$\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) + \frac{1}{2}Br_2(g) \rightleftharpoons NOBr(g)$$
   From the following data at 298 K.
   (i) $2NO \rightleftharpoons N_2 + O_2$; $K_C = 2.4 \times 10^{30}$
   (ii) $NO + \frac{1}{2}Br_2 \rightleftharpoons NOBr$; $K_C = 1.4$
5. The reaction $CuSO_4 \cdot 3H_2O(s) \rightleftharpoons CuSO_4 \cdot H_2O(s) + 2H_2O(g)$; the dissociation pressure is 7×10^{-3} atm at 25°C and $\Delta H° = 2750$ cal. What will be the dissociation pressure at 127°C?

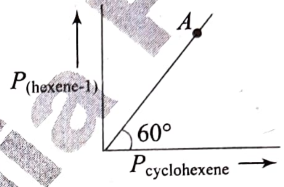
Single Correct Answer Type

6. Variation of log *K* with 1/*T* is shown in the following graph. ΔH° for the reaction will be:



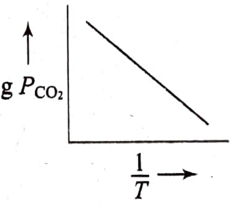
(a) -19.14 J mol^{-1}
(b) $+19.14$ J mol^{-1}
(c) $+4.606$ cal mol^{-1}
(d) -2 cal mol^{-1}

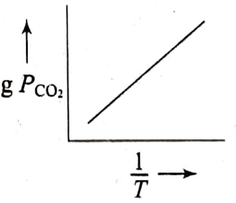
7. For the following isomerisation reaction:
   Cyclohexane $\rightleftharpoons$ hexane-1, $K = 1.732$

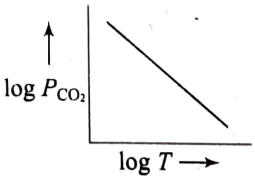


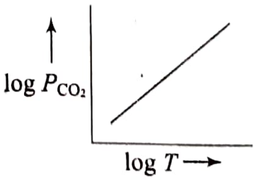
Which of the following statements holds good at point 'A'?
(a) $Q > K$
(b) $Q < K$
(c) $Q = K = 1$
(d) $Q = K = 1.732$

8. For the chemical equilibrium,
   $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$,
   ΔH° can be determined from which one of the following graphs?

(a)


(b)


(c)


(d)


9. While solid balls of naphthalene ($C_{10}H_8$) used as moth balls were kept in a closed container at room temperature (27°C). The vapour pressure above the balls was found to be 0.10 mm Hg. The value of K_c for the sublimation equilibrium, $C_{10}H_8(s) \rightleftharpoons C_{10}H_8(V)$ is

(a) 1.32×10^{-4} (b) 5.36×10^{-6}
(c) 3.4×10^{-7} (d) 0.10

10. The equilibrium constant (K_c) for the reaction $N_2(g) + O_2(g) \rightarrow 2NO(g)$ at temperature T is 4×10^{-4}. The value of K_c for the reaction $NO(g) \rightarrow 1/2N_2(g) + 1/2O_2(g)$ at the same temperature is
(a) 50.0 (b) 0.02
(c) 2.5×10^2 (d) 4×10^{-4}

11. Consider the following reactions in which all the reactants and the products are in gaseous state.

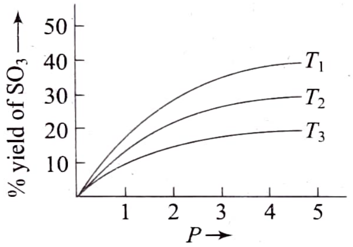
$$2PQ \rightleftharpoons P_2 + Q_2; \qquad K_1 = 2.5 \times 10^5$$

$$PQ + \frac{1}{2}R_2 \rightleftharpoons PQR, \qquad K_2 = 5 \times 10^{-3}$$

The value of K_3 for the equilibrium
$1/2P_2 + 1/2Q_2 + 1/2R_2 \rightleftharpoons PQR$, is
(a) 2.5×10^{-3} (b) 2.5×10^3
(c) 1.0×10^{-5} (d) 5×10^3

12. The preparation of $SO_3(g)$ by the reaction,

$$SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g)$$



shows the following figure in % yield against pressure at different temperature, then:
(a) $T_3 > T_2 > T_1$ (b) $T_1 > T_2 > T_3$
(c) $T_1 = T_2 = T_3$ (d) $T_2 > T_1 > T_3$

13. The value of K_p for the reaction,
$2H_2O(g) + 2Cl_2(g) \rightleftharpoons 4HCl(g) + O_2(g)$
is 0.03 atm at 427°C, when the partial pressure are expressed in atmosphere, then the value of K_C for the same reaction is
(a) 5.23×10^{-4} (b) 7.34×10^{-4}
(c) 3.2×10^{-3} (d) 5.43×10^{-5}

14. The equilibrium constant of the reaction $SO_2(g) + ½O_2(g) \rightleftharpoons SO_3(g)$ is 4×10^{-3} atm$^{-1/2}$. The equilibrium constant of the reaction $2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$ would be:
(a) 250 atm (b) $4 \times 10 + 3$ atm
(c) 0.25×10^4 atm (d) 6.25×10^4 atm

15. The equilibrium constant for, $2H_2S(g) \rightleftharpoons 2H_2(g) + S_2(g)$ is 0.0118 at 1300 K while the heat of dissociation is 597.4 kJ. The standard equilibrium constant of the reaction at 1200 K is:
(a) 1.180×10^{-4}
(b) 11.80
(c) 118.0
(d) cannot be calculated from given data

16. For the reaction,
$A(g) + B(g) \rightleftharpoons C(g) + D(g)$ at 298 K, the values of $\Delta H°$ and $\Delta S°$ are -29.8 kcal and -0.1 kcal K^{-1} respectively. The values of $\Delta G°$ and equilibrium constant K_C are
(a) 1, 2 respectively (b) 0, 2 respectively
(c) 0, 1 respectively (d) 0, 0 respectively

17. When ethanol and acetic acid were mixed together in equilimolar proportion 66.6% are converted into ethyl acetate. Calculate K_C. Also calculate quantity of ester produced if one mole of acetic acid is treated with 0.5 mole and 4 mole of alcohol respectively.
(a) 4, 0.93, 0.43 (b) 0.93, 4, 0.43
(c) 0.43, 0.93, 4 (d) 4, 0.43, 0.93

18. In an aqueous solution of volume 500 mL, when the reaction of $2Ag^+ + Cu \rightleftharpoons Cu^{2+} + 2Ag$ is reached the equilibrium $[Cu^{2+}]$ was x M. When 500 mL of water is further added, at the equilibrium $[Cu^{2+}]$ will be
(a) $2x$ M (b) xM
(c) between xM and $x/2$ M(d) less than $x/2$ M

19. Consider following reactions in equilibrium concentration 0.01 M of every species.
(I) $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$
(II) $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$
(III) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
Extent of the reactions taking place is
(a) I > II > III (b) I < II < III
(c) II < III < I (d) III < I < II

Multiple Correct Answers Type

20. For the reaction $N_2O_4(g) \rightleftharpoons 2NO_2(g)$, the value of K is 50 at 400 K and 1700 at 500 K. Which of the following option(s) is/are correct?
(a) The reaction is endothermic
(b) The reaction is exothermic
(c) If NO_2 (g) and N_2O_4(g) are mixed at 400 K at partial pressures 20 bar and 2 bar respectively, more N_2O_4(g) will be formed.
(d) The entropy of the system increases

21. A reaction $S_8(g) \rightleftharpoons 4S_2(g)$ is carried out by taking 2 moles of $S_8(g)$ and 0.2 mole of $S_2(g)$ in a reaction vessel of 1 litre. Which are correct if $K_C = 6.30 \times 10^{-6}$?
(a) reaction quotient is 8×10^{-4}
(b) reaction proceeds in backward direction
(c) $K_p = 2.55$ atm^3
(d) reaction proceeds in forward direction

22. (a) $N_2(g) + O_2(g) \rightleftharpoons 2NO(g); K_1$
(b) $\left(\frac{1}{2}\right)N_2(g) + \left(\frac{1}{2}\right)O_2(g) \rightleftharpoons NO(g); K_2$
(c) $2NO_2(g) \rightleftharpoons N_2(g) + O_2(g); K_3$
(d) $NO(g) \rightleftharpoons \left(\frac{1}{2}\right)N_2(g) + \left(\frac{1}{2}\right)O_2(g)$; K_4

The correct relation between K_1, K_2 and K_4 is/are:

(a) $K_1 \times K_3 = 1$ (b) $\sqrt{K_1} \times K_4 = 1$

(c) $\sqrt{K_3} \times K_2 = 1$ (d) None

Matching Column Type

23. Match the following:

	Column I		Column II
A.	$Cu + 2Ag^+ \rightleftharpoons Cu^{2+} + 2Ag$ Concs : 3.0×10^{-9} M Equilibrium const. = 2.0×10^{15}	p.	Reaction will shift forward
B.	$H_2 + I_2 \rightleftharpoons 2HI$ 10^{-2} 3.0×10^{-2} 2.0×10^{-2} Concs. (Moles) Volume of vessel = 2 L Equilibrium constant = 50.5	q.	Reaction will shift backward
C.	$N_2 + 3H_2 \rightleftharpoons 2NH_3$ 0.5 3.0 0.5 Pressure (atm) $K_p = 4.28 \times 10^{-5}$	r.	Reaction is in equilibrium
D.	$PCl_5 \rightleftharpoons PCl_3 + Cl_2$ Helium gas is added to the reaction mixture at equilibrium keeping the pressure constant.	s.	Reaction may shift in the forward or backward direction.

(a) A→r, B→p, C→q, D→r
(b) A→p, B→p, C→q, D→r
(c) A→q, B→p, C→q, D→r
(d) A→r, B→p, C→q, D→p

Integer Type

24. If the equilibrium constant of the reaction $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$ is 0.25, the equilibrium constant of the reaction $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ will be ________.

25. For the reaction involving oxidation of ammonia by oxygen to form nitric oxide and water vapour, the equilibrium constant has the units $(bar)^n$. Then n is.........

26. For the equilibrium of the reaction,
$NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$, $K_p = 81\ atm^2$
Total pressure equilibrium will be x times the pressure of NH_3. The value of x will be ________.

Comprehension Type

Effect of temperature on the equilibrium process is analysed by using the thermodynamics.

From the thermodynamics relation,

$$\Delta G^\circ = -2.30\ RT \log k \qquad (1)$$

ΔG°: Standard free energy change

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ \qquad (2)$$

ΔH°: Standard heat of the reaction.

From (1) and (2)

$-2.3\ RT \log K = \Delta H^\circ - T\Delta S^\circ$

ΔS°: Standard entropy change

$$\Rightarrow \quad \log K = -\frac{\Delta H^\circ}{2.3RT} + \frac{\Delta S^\circ}{2.3R} \qquad (3)$$

Clearly if a plot of log K vs $1/T$ is made then it is a straight line having slope = $\frac{-\Delta H^\circ}{2.3R}$ and Y intercept = $\frac{\Delta S^\circ}{2.3R}$

If at temperature T, equilibrium constant be K_1 and at temperature T_2 equilibrium constant be K_2, then the above equation reduces to:

$$\Rightarrow \quad \log K_1 = -\frac{\Delta H^\circ}{2.3RT_1} + \frac{\Delta S^\circ}{2.3R} \qquad (4)$$

$$\Rightarrow \quad \log K_2 = -\frac{\Delta H^\circ}{2.3RT_2} + \frac{\Delta S^\circ}{2.3R} \qquad (5)$$

Subtracting (4) from (5), we get

$$\Rightarrow \quad \log\frac{K_2}{K_1} = \frac{\Delta H^\circ}{2.30R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

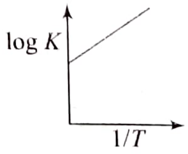
From the above relation, we can conclude that the value of equilibrium constant increases with increase in temperature for endothermic reaction but value of equilibrium constant decreases with the increase in temperature for exothermic reaction.

27. If standard heat of dissociation of PCl_5 is 230, then slope of the graph of log K vs $\frac{1}{T}$ is:

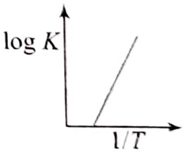
(a) +50 (b) −50 (c) 10 (d) None

28. For exothermic reaction if $\Delta S_0 < 0$, then the sketch of log K vs $\frac{1}{T}$ may be:

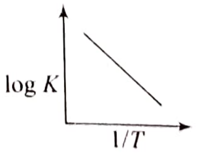
(a)



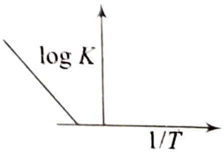
(b)



(c)



(d)



29. If for a particular reversible reaction at:
$K_C = 57$ at 355°C and $K_C = 69$ at 450°C, then:

(a) $\Delta H < 0$
(b) $\Delta H > 0$
(c) $\Delta H = 0$
(d) ΔH whose sign cannot be determined

Answers Key

Subjective Type

1. 52.898 kJ mol^{-1} **2.** 11
3. (a) reactants (b) products
(c) Same for both reactants and products
4. 9×10^{-16}
5. 1.26×10^{-2} atm

Single Correct Answer Type

6. (a) **7.** (d) **8.** (a) **9.** (b) **10.** (a)
11. (c) **12.** (a) **13.** (a) **14.** (d) **15.** (a)
16. (c) **17.** (d) **18.** (d) **19.** (b)

Multiple Correct Answers Type

20. (a, c, d) **21.** (a, c, d)
22. (a, b, c)

Matching Column Type

23. (d)

Integer Type

24. (4) **25.** (1) **26.** (2)

Comprehension Type

27. (b) **28.** (b) **29.** (b)

DPP 6.3

Le Chatelier's Principle

Subjective Type

1. Consider the reaction,

$$2Cl_2(g) + 2H_2O(g) \rightleftharpoons 4HCl(g) + O_2(g); \quad \Delta H^\circ = +133 \text{ kJ}$$

The four gases, Cl_2, H_2O, HCl and O_2, are mixed and the reaction is allowed to come to equilibrium. State and explain the effect (increase, decrease, no change) of the operation in the left column (below) on the equilibrium value of the quantity in the right column. Each operation is to be considered separately. Temperature and volume are constant unless stated otherwise.

(a) Increasing the volume of the container	Number of moles of H_2O
(b) Adding O_2	Number of moles of H_2O
(c) Adding O_2	Number of moles of HCl
(d) Decreasing the volume of the container	Number of moles of Cl_2
(e) Decreasing the volume of the container	Number of moles of Cl_2
(f) Decreasing the volume of the container	K_C
(g) Raising the temperature	K_C
(h) Raising the temperature	Concentration of HCl
(i) Adding He	Number of moles of HCl
(j) Adding catalyst	Number of moles of HCl

2. Under what conditions will the following reactions go in the forward direction?
   (a) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) + 23$ kcal
   (b) $N_2(g) + O_2(g) \rightleftharpoons 2NO(g) - 43.2$ kcal
   (c) $C(s) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g) + X$ kcal
   (d) $N_2O_4(g) \rightleftharpoons 2NO_2(g) - 14$ kcal

3. Which of the following reactions will get affected by increasing the pressure? Also mention whether change will cause the reaction to go into forward or backward direction?
   (i) $COCl_2(g) \rightleftharpoons CO(g) + Cl_2(g)$
   (ii) $CH_4(g) + 2S_2(g) \rightleftharpoons CS_2(g) + 2H_2S(g)$
   (iii) $CO_2(g) + C(s) \rightleftharpoons 2CO(g)$
   (iv) $2H_2(g) + CO(g) \rightleftharpoons CH_3OH(g)$
   (v) $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$
   (vi) $4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$

Single Correct Answer Type

4. The following two equilibria exist simultaneously in a closed vessel:

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$
$$COCl_2(g) \rightleftharpoons CO(g) + Cl_2(g)$$

If some CO is added into the vessel, then after the equilibrium is attained again, concentration of
   (a) PCl_5 will increase
   (b) PCl_5 will decrease
   (c) PCl_5 will remain unaffected
   (d) Cl_2 will increase

5. To an equilibrium mixture of

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

some helium, an inert gas, is added at constant volume. The addition of helium causes the total pressure to double. Which of the following is true?
   (a) The concentration of the three gases is unchanged
   (b) The concentration of sulphur trioxide increases
   (c) The number of moles of sulphur trioxide increases
   (d) The concentration of sulphur dioxide increases

6. According to Le Chatelier's principle, adding heat to a solid to liquid in equilibrium will causes the
   (a) Temperature to increase
   (b) Temperature to decrease
   (c) Amount of liquid to increase
   (d) Amount of solid to increase

7. When hydrochloric acid is added to cobalt nitrate solution at room temperature, the following reaction takes place and the reaction mixture becomes blue. On cooling the mixture it becomes pink. On the basis of this information mark the correct answer.

$$\underset{\text{(Pink)}}{[Co(H_2O_6)]^{3+}(aq)} + 4Cl^-(aq) \rightleftharpoons \underset{\text{(Blue)}}{[CoCl_4]^{2-}(aq)} + 6H_2O(l)$$

   (a) $\Delta H > 0$ for the reaction
   (b) $\Delta H < 0$ for the reaction

(c) $\Delta H = 0$ for the reaction
(d) The sign of ΔH cannot be predicted on the basis of this information

8. On increasing the pressure, in which direction will the gas phase reaction proceed to re-establish, is predicted by applying the Le Chatelier's principle. Consider the reaction,

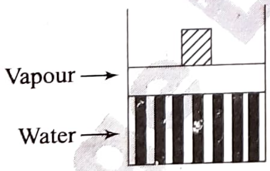
$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

Which of the following is correct, if the total pressure at which the equilibrium is established, is increased without changing the temperature?
(a) *K* will remain same
(b) *K* will decrease
(c) *K* will increase
(d) *K* will increase initially and decrease when pressure is very high.

9. For an equilibrium $H_2O \rightleftharpoons H_2O(l)$, which of the following statements is true?
(a) The pressure changes do not affect the equilibrium
(b) More of ice melts if pressure on the system is increased
(c) More of liquid freezes if pressure on the system is increased
(d) The pressure changes may increase or decrease the degree of advancement of the reaction depend upon the temperature of the system

10. The equilibrium, $SO_2Cl_2(g) \rightleftharpoons SO_2(g) + Cl_2(g)$ is attained at 25°C in a closed container and an inert gas, helium, is introduced. Which of the following statement(s) is/are correct?
(a) Concentrations of SO_2, Cl_2 and SO_2Cl_2 are changed
(b) No effect on equilibrium
(c) Concentration of SO_2 is reduced
(d) K_p of reaction is increasing

11. Some quantity of water is contained in a container as shown as shown in figure. As neon is added to this system at constant pressure, the amount of liquid water in the vessel



(a) increases (b) decreases
(c) remains same (d) changes unpredictably

Multiple Correct Answers Type

12. The equilibrium $2Cu^{I} \rightleftharpoons Cu^{0} + Cu^{II}$ in aqueous medium at 25°C shifts towards the left in the presence of
(a) NO_3^- (b) Cl^- (c) SCN^- (d) CN^-

13. The thermal dissociation equilibrium of $CaCO_3(s)$ is studied under different conditions

$$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$$

For this equilibrium, the correct statement (s) is (are)
(a) ΔH is dependent on T
(b) K is independent of the initial amount of $CaCO_3$
(c) K is dependent on the pressure of CO_2 at a given T
(d) ΔH is independent of the catalyst, if any

14. When $NaNO_3$ is heated in a closed vessel, oxygen is liberated and $NaNO_2$ is left behind. At equilibrium

$$NaNO_3(s) \rightleftharpoons NaNO_2(s) + \frac{1}{2}O_2(G)$$

(a) addition of $NaNO_2$ favours reverse reaction
(b) addition of $NaNO_3$ favours forwards reaction
(c) increasing temperature favours forward reaction
(d) increasing pressure favours reverse reaction

15. An industrial fuel, 'water gas', which consists of a mixture of H_2 and CO can be made by passing steam over red-hot carbon. The reaction is

$$C(S) + H_2O(g) \rightleftharpoons CO(g) + H_2(g),\ \Delta H = +131\ kJ$$

The yield of CO and H_2 at equilibrium would be shifted to the product side by:
(a) raising the relative pressure of the steam
(b) adding hot carbon
(c) raising the temperature
(d) reducing the volume of the system

16. The reactions in which the yield of the products cannot be increased by the applying of high pressure are:
(a) $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$
(b) $NH_4HS(s) \rightleftharpoons NH_3(g) + H_2S(g)$
(c) $N_2O_4(g) \rightleftharpoons 2NO_2(g)$
(d) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

17. For the reaction : $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$
The forward reaction at constant temperature is favoured by
(a) introducing chlorine gas at constant volume
(b) introducing an inert gas at constant pressure
(c) increasing the volume of the container
(d) introducing PCl_5 at constant volume

18. For the reaction

$$2A(g) + B(g) \rightleftharpoons 2C(g): \Delta H = +13.6\ kJ$$

Which of the following will increase the extent of the reaction at equilibrium?
(a) Increasing the temperature
(b) Increasing the pressure
(c) Addition of catalyst
(d) All of these

Matching Column Type

19. Match the following:

	Column I (Assume only reactant were present initially)		**Column II**
a.	For the equilibrium $NH_4I(s) \rightleftharpoons NH_3(g) + HI(g)$, if pressure is increased at equilibrium	p.	Forward shift

b.	For the equilibrium $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ volume is increased at equilibrium	q.	No change
c.	For the equilibrium $H_2O(g) + CO(g) \rightleftharpoons H_2(g) + CO_2(g)$ inert gas is added at constant pressure at equilibrium	r.	Backward shift
d.	For the equilibrium $PCl_5 \rightleftharpoons PCl_3 + Cl_2$ Cl_2 is removed at equilibrium.	s.	Final pressure is more than initial pressure

Comprehension Type

If a system at equilibrium is subjected to a change of any one of the factors such as concentration, pressure or temperature, the system adjusts itself in such a way as to nullify the effect of that change.

Change of pressure: If a system in equilibrium consists of gases, then the concentrations of all the components can be altered by changing the pressure. To increase the pressure on the system, the volume has to be decreased proportionately. The total number of moles per unit volume will now be more and the equilibrium will shift in the direction in which there is decrease in number of moles i.e., towards the direction in which there can be decrease in pressure.

Effect of pressure on melting point: There are two types of solids

(a) Solid whose volume decreases on melting, e.g., ice, diamond, carborundum, magnesium nitride and quartz.
Solid (higher volume) $\rightleftharpoons$ Liquid (lower volume)

(b) Solids whose volume increase on melting, e.g., Fe, Cu, Ag, Au, etc.
Solid (lower volume) $\rightleftharpoons$ Liquid (higher volume)
In this case the process of melting become difficult at high pressure, thus melting point becomes high.

(c) Solubility of substances: When solid substance are dissolved in water, either heat is evolved (exothermic) or heat is absorbed (endothermic).
$KCl + aq \rightleftharpoons KCl\,(aq) - heat$
In such cases, solubility increases with increase in temperature. Consider the case of KOH, when this is dissolved, heat is evolved.
$KOH + aq \rightleftharpoons KOH\,(aq) + heat$
In such cases, solubility decreases with increase in temperature.

(d) Solubility of gases in liquids : When a gas dissolves in liquid, there is a decrease in volume. Thus, increase of pressure will favour the dissolution of gas in liquid.

20. A gas 'X' when dissolved in water heat is evolved. Then solubility of 'X' will increase:
(a) Low pressure, high temperature
(b) Low pressure, low temperature
(c) High pressure, high temperature
(d) High pressure, low temperature

21. $Au(s) \rightleftharpoons Au(l)$
The above equilibrium is favoured at:
(a) High pressure, low temperature
(b) High pressure, high temperature
(c) Low pressure, high temperature
(d) Low pressure, low temperature

22. For the reaction, $\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons NO(g)$
If pressure is increased by reducing the volume of the container, then:
(a) Total pressure at equilibrium will change.
(b) Concentration of all the component at equilibrium will change.
(c) Concentration of all the component at equilibrium will remain same
(d) Equilibrium will shift in the forward direction

Answers Key

Subjective Type

2. (a)

Single Correct Answer Type

4. (b) **5.** (a) **6.** (c) **7.** (a) **8.** (a)
9. (b) **10.** (b) **11.** (b)

Multiple Correct Answers Type

12. (b, c, d) **13.** (a, b, d)
14. (c, d) **15.** (a, c)
16. (b, c) **17.** (b, c, d)
18. (a, b)

Matching Column Type

19. (a→r), (b→r), (c→q), (d→p)

Comprehension Type

20. (d) **21.** (c) **22.** (a, b)

DPP 6.4

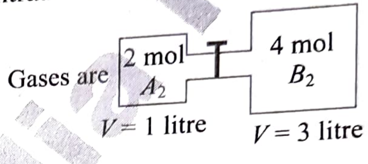
Degree of Dissociation and Vapour Density

Subjective Type

1. The degree of dissociation of N_2O_4 into NO_2 at one atmospheric pressure and 313 K is 0.310. Calculate K_p of the dissociation reaction at this temperature. What will be the degree of dissociation at 10 atmospheric pressure at the same temperature?
2. At 77°C and one atmospheric pressure, N_2O_4 is 70% dissociated into NO_2. What will be the volume occupied by the mixture under these conditions if we start with 10 g of N_2O_4?
3. For the equilibrium
   $LiCl.3NH_3(s) \rightleftharpoons LiCl.NH_3(s) + 2NH_3$
   $K_p = 9\ atm^2$, at 40°C. A 5 litre contains 0.1 mole of $LiCl.NH_3$. How many moles of NH_3 should be added to the flask at this temperature to drive the backward reaction for completion?
4. At temperature T, the compound $AB_2(g)$ dissociates according to the reaction; $2AB_2(g) \rightleftharpoons 2AB(g) + B_2(g)$. With a degree of dissociation x, which is small compared with unity. Deduce the expression for x in terms of the equilibrium constant, K_p and the total pressure, P.
5. Vapour density of the equilibrium mixture of NO_2 and N_2O_4 is found to be 38.33. For the equilibrium
   $N_2O_4(g) \rightleftharpoons 2NO_2(g)$.
   Calculate:
   (a) abnormal molecular weight
   (b) degree of dissociation
   (c) percentage of NO_2 in the mixture
   (d) K_P for the reaction if total pressure is 2 atm.
6. At 700 K, CO_2 and H_2 react to form CO and H_2O. For this purpose K_c is 0.11. If a mixture of 0.45 mole of CO_2 and 0.45 mole of H_2 is heated to 700 K,
   (a) find out the amount of each gas at equilibrium.
   (b) when equilibrium has been reached, another 0.34 mole of CO_2 and 0.34 mole of H_2 are added to the reaction mixture. Find the composition of mixture at new equilibrium.

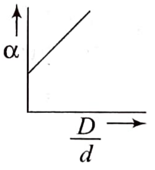
Single Correct Answer Type

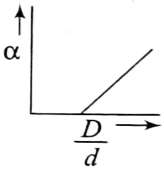
7. Gases are present in two containers at 300 K separated by a narrow tube of negligible volume having valve in between. On opening the valve, the reaction $A_2(g) + B_2(g) \rightleftharpoons 2AB(g)$ attains equilibrium at 300 K. If $K_C = 4$ at 300 K, the concentration of AB at equilibrium is:

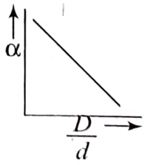


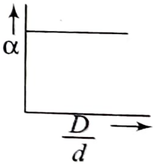
(a) 1.33 M (b) 2.66 M (c) 1.66 M (d) 0.66 M

8. 10% of a mixture of 0.2 mole of N_2 and 0.6 mole of H_2 react to give NH_3 according to the equation to give NH_3 the following reaction equilibrium:
   $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
   at constant temperature. The ratio between the initial moles and final mole is:
   (a) 1.05 (b) 2.20 (c) 0.8 (d) 0.6
9. In the above question, α varies with $\frac{D}{d}$ according to:

(a)


(b)


(c)


(d)


10. $N_2 + 3H_2 \rightleftharpoons 2NH_3$
    1 mole N_2 and 3 mole H_2 are present at start in 1 L flask. At equilibrium NH_3 formed required 100 mL of 5M HCl for neutralisation. Hence K_C is
    (a) $\frac{(0.5)^2}{(0.75)(2.25)^3}$ (b) $\frac{(0.5)^2}{(0.5)(2.5)^3}$
    (c) $\frac{(0.5)L}{(0.75)(2.5)^3}$ (d) none of these
11. For the equilibrium $2NOBr(g) \rightleftharpoons 2NO(g) + Br_2(g)$, calculate the ratio $\frac{K_P}{P}$, where P is the total pressure and $P_{Br_2} = \frac{P}{9}$ at a certain temperature.

(a) $\frac{1}{9}$ (b) $\frac{1}{81}$ (c) $\frac{1}{27}$ (d) $\frac{1}{3}$

12. For the reaction : $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$, the degree of dissociated (α) of HI(g) is related to equilibrium constant K_p by the expression

(a) $\frac{1+2\sqrt{K_p}}{2}$ (b) $\sqrt{\frac{1+2K_p}{2}}$

(c) $\sqrt{\frac{2K_p}{1+2K_p}}$ (d) $\frac{2\sqrt{K_p}}{1+2\sqrt{K_p}}$

13. At 727°C and 1.23 atm of total equilibrium pressure, SO_3 is partially dissociated into SO_2 and O according to $SO_3(g) \rightleftharpoons SO_2(g) + 1/2O_2(g)$. The density of equilibrium mixture is 0.9 gm/litre. The degree of dissociation is:

(a) 1/3 (b) 2/3 (c) 1/4 (d) 1/5

14. The formation constant of $Ni(NH_3)_6^{2+}$ is 6×10^8 at 25°C. If 50 mL of 2.0 M NH_3 is added to 50 mL of 0.20 M solution of Ni^{2+}, the concentration of Ni^{2+} ion will be nearly equal to:

(a) 3×10^{-10} mole litre^{-1} (b) 2×10^{-10} mole litre^{-1}

(c) 2×10^{-9} mole litre^{-1} (d) 4×10^{-8} mole litre^{-1}

15. The vapour density of N_2O_4 at a certain temperature is 30. What is the % dissociation of N_2O_4 at this temperature?

(a) 53.3% (b) 106.6%

(c) 26.7% (d) None of these

Multiple Correct Answers Type

16. The equation $\alpha = \frac{D-d}{(n-1)d}$ is correctly matched for:

(a) $A(g) \rightleftharpoons nB/2(g) + nC/3(g)$

(b) $A(g) \rightleftharpoons nB/3(g) + (2n/3)C(g)$

(c) $A(g) \rightleftharpoons (n/2)B(g) + (n/4)C(g)$

(d) $A(g) \rightleftharpoons (n/2)B(g) + C(g)$

17. 138 g of N_2O_4 (g) is placed in 8.2 L container at 300 K. The equilibrium vapour density of mixture was found to be 30.67. Then ($R = 0.082$ L atm mol^{-1} K^{-1})

(a) a = degree of dissociation of $N_2O_4 = 0.25$

(b) K_p of $N_2O_4 \rightleftharpoons 2NO_2(g)$ will be 9 atm

(c) Total pressure at equilibrium = 6.75 atm

(d) The density of equilibrium mixture will be 16.83 g/litre

Matching Column Type

18. Match the following:

	Column I (Reaction)		Column II (Degree of dissociation)
a.	$2NH_3 \rightleftharpoons N_2 + 3H_2$	p.	$\frac{D-d}{2d}$
b.	$N_2O_4 \rightleftharpoons 2NO_2$	q.	$\frac{D-d}{d}$
c.	$4PH_3 \rightleftharpoons P_4 + 6H_2$	r.	$\frac{D-d}{3d}$
d.	$5A \rightleftharpoons 6B + 9C$	s.	$\frac{4(D-d)}{3d}$

Integer Type

19. Mixing 4 moles of A with 4 moles of B forms 2 moles of C at equilibrium, according to the reaction:

$$A(g) + B(g) \rightleftharpoons C(g) + D(g),$$

The value of equilibrium constant is ______ .

20. What weight of solid ammonium carbamate (NH_2COONH_4) when vaporized at 200°C will have a volume of 8.96 litre at 1 atm? Assume that solid completely decomposes into CO_2 and NH_3 at 200°C and 1 atm.

Comprehension Type

Passage 1:

10 mole of NH_3 is heated at 15 atm from 27° to 347°C assuming volume constant. The pressure at equilibrium is found to be 50 atm. The equilibrium constant for dissociation of NH_3:

$$2NH_3 \rightleftharpoons N_2 + 3H_2;\ \Delta H = 91.94 \text{ kJ}$$

can be written as $K_p = \frac{P_{N_2} \times (P_{H_2})^3}{(P_{H_3})^2}(\text{atm})^2$

21. The degree of dissociation of NH_3 is:

(a) 61.3% (b) 20%

(c) 48% (d) none of these

22. The equilibrium constant K_p for the reaction is:

(a) 7.08×10^2 (b) 3.06×10^2

(c) 7.6×10^2 (d) 1.53×10^3

23. The volume of container in which gas is heated is:

(a) 16.42 litre (b) 8.21 litre

(c) 20 litre (d) 15 litre

24. The increase in pressure and temperature on the reaction in equilibrium favours:

(a) forward reaction in both cases

(b) less dissociation of NH_3

(c) backward reaction and forward reaction respectively

(d) more formation of N_2 but less formation of H_2

25. The vapour density of mixture at equilibrium is:

(a) 6.97 (b) 28.42 (c) 14.14 (d) 5.27

26. The change in internal energy (in kJ) during the reaction is:

(a) 91.94 kJ (b) 81.63 kJ

(c) 102.25 kJ (d) 86.20 kJ

27. The equilibrium constant for NH_3 at 247°C would be:

(a) 49.58 atm^2 (b) 45.28 atm^2

(c) 54.98 atm^2 (d) 40.18 atm^2

Passage 2:

The vapour density of PCl_5 at 200°C and 252°C are 70.2 and 57.2 respectively at one atmosphere.

28. The observation shows that the dissociation constants for the reaction are
- (a) 1 and 2 respectively
- (b) 1.19 and 0.37 respectively
- (c) 0.235 and 0.676 respectively
- (d) 2 and 1 respectively

29. This observation shows that
- (a) The reaction is endothermic
- (b) The reaction is exothermic
- (c) The reaction is not affected by change in pressure
- (d) The reaction is not affected by adding inert gas at constant pressure

30. It can also be concluded that
- (a) As dissociation increases, vapour density increases
- (b) Vapour density of mixture is more than the vapour density in pure state
- (c) Vapour density of mixture is less than the vapour density in pure state
- (d) None of these

Answers Key

Subjective Type

1. 10.3% **2.** 5.32 L **3.** 0.7837 mole

4. $x = \left(\dfrac{2K_p}{p}\right)^{\frac{1}{3}}$

5. (a) 76.66 (b) 0.2 (c) 33.33% (d) 0.33

6. (a) 0.112 mole (b) (i) $n_{CO_2} = n_{H_2} = 0.34$

Single Correct Answer Type

7. (d) **8.** (a) **9.** (b) **10.** (a) **11.** (b)
12. (d) **13.** (b) **14.** (d) **15.** (a)

Multiple Correct Answers Type

16. (a, b) **17.** (b, c, d)

Matching Column Type

18. (a → q), (b → q), (c → s), (d → p)

Integer Type

19. (1) **20.** (6)

Comprehension Type

21. (a) **22.** (d) **23.** (a) **24.** (c) **25.** (d)
26. (b) **27.** (a) **28.** (c) **29.** (a) **30.** (c)

DPP 6.5

Simultaneous Equilibria

Subjective Type

1. Two solids A and D dissociates into gaseous products as follows:

$A(s) \rightleftharpoons B(g) + C(g);\ K_{P_1} = 300.$

$;\ D(s) \rightleftharpoons E(g) + C(g);\quad K_{P_2} = 600$

at 27°C, then find the total pressure of the solid mixture.

2. Two solid compounds A and B dissociate into gaseous products at 20°C as

(i) $A(s) \rightleftharpoons A'(g) + H_2S(g)$

(ii) $B(s) \rightleftharpoons B'(g) + H_2S(g)$

At 20°C pressure over excess solid A is 50 mm and that over excess solid B is 68 mm, find:

(a) The dissociation constant of A and B

(b) Relative no. of moles of A′ and B′ in the vapour phase over a mixture of solid A and B.

(c) Show that the total pressure of the gas over the solid mixture would be 84.4 mm

3. In a vessel, two equilibriums are simultaneously established at the same temperature as follows:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad (1)$$

$$N_2(g) + 2H_2(g) \rightleftharpoons N_2H_4(g) \qquad (2)$$

Initially the vessel contains N_2 and H_2 in the molar ratio of 9:13. The equilibrium pressure is $7P_0$, in which pressure due to ammonia is P_0 and due to hydrogen is $2P_0$. Find the values of equilibrium constants (K_p's) for both the reactions.

Single Correct Answer Type

4. For the equilibrium $SrCl_2 \cdot 6H_2O(s) \rightleftharpoons SrCl_2 \cdot 2H_2O(s) + 4H_2O(g)$ the equilibrium constant $K_P = 16 \times 10^{-12}$ atm^4 at 1°C. If one litre of air saturated with water vapour at 1°C is exposed to a large quantity of $SrCl_2 \cdot 2H_2O(s)$, what weight of water vapour will be absorbed? Saturated vapour pressure of water at 1°C = 7.6 torr.

(a) 6 g (b) 6.4 mg (c) 2.3 g (d) 8.5 g

5. For the equilibrium $CuSO_4 \cdot 5H_2O(s) \rightleftharpoons CuSO_4 \cdot 3H_2O(s) + 2H_2O(g)$ $K_P = 2.25 \times 10^{-4}$ atm^2 and vapour pressure of water is 22.8 Torr at 298 K. $CuSO_4.5H_2O(s)$ is efflorescent (i.e., loses water) when relative humidity is:

(a) less than 63.3% (b) less than 50%

(c) less than 66.6% (d) above 66.6%

6. Equilibrium constant for the following equilibrium is given at 0°C.

$Na_2HPO_4 \cdot 12H_2O(s) \rightleftharpoons Na_2HPO_4 \cdot 7H_2O(s) + 5H_2O(g);$

$K_P = 31.25 \times 10^{-13}$

the pressure of water vapour is

(a) $\frac{1}{5} \times 10^{-3}$ atm (b) 0.5×10^{-3} atm

(c) 5×10^{-2} atm (d) 5×10^{-5} atm

7. The two equilibria, $AB \rightleftharpoons A^+ + B^-$ and $AB + B^- \rightleftharpoons AB_2^-$ are simultaneously maintained in a solution with equilibrium constants K_1 and K_2 respectively. The ratio of A^+ to AB_2^- in the solution is

(a) Directly proportional to the concentration of B

(b) Inversely proportional to the concentration of B

(c) Directly proportional to the square of the concentration of B

(d) Inversely proportional to the square of the concentration of B

8. In the proceeding problem, if $[A^+]$ and $[AB_2^-]$ are y and x respectively, under equilibrium produced by adding the substance AB to the solvents, then K_1/K_2 is equal to

(a) $\frac{y}{x}(y-x)^2$ (b) $\frac{y^2(x+y)}{x}$

(c) $\frac{y^2(x+y)}{x}$ (d) $\frac{y}{x}(y-x)$

Multiple Correct Answers Type

9. The two equilibriums, $AB \rightleftharpoons A^+ + B^-$ and $AB + B^- \rightleftharpoons AB_2^-$ are simultaneously maintained in a solution with equilibrium constants, k_1 and k_2 respectively. If $[A^+]$ and $[AB_2^-]$ are y and x respectively, under equilibrium produced by adding the substance AB(s) to the solvents, then

(a) $\frac{k_1}{k_2} = \frac{y}{x}(y-x)^2$ (b) $\frac{k_1}{k_2} = \frac{y}{x}(x-y)$

(c) $[B^-]_{eq.} = y - x$ (d) None of these

Comprehension Type

When a reversible reaction is carried out in a closed vessel a stage is reached when the forward and the backward reactions proceed with the same rate. This stage is known as chemical equilibrium.

Following are the equilibriums at 0°C

$$SrCl_2.6H_2O(s) \rightleftharpoons SrCl_2.2H_2O(s) + 4H_2O(g); \quad K_p = 1.6 \times 10^{-15}$$

$$Na_2HPO_4.12H_2O(s) \rightleftharpoons Na_2HPO_4.7H_2O(s) + 5H_2O(g); \quad K_p = 2.43 \times 10^{-8}$$

$$Na_2SO_4.10H_2O(s) \rightleftharpoons Na_2SO_4(s) + 10H_2O(g); \quad K_p = 10^{-30}$$

The vapour pressure of water at 0°C is 4.58 torr.

10. Which is the most effective drying agent at 0°C?

(a) $SrCl_2.2H_2O(s)$ (b) $Na_2HPO_4.7H_2O(s)$

(c) $Na_2SO_4(s)$ (d) All equally

11. $Na_2SO_4.10H_2O(s)$ will be efflorescent when exposed to the air at 0°C at:

(a) Pressure below 0.76 torr

(b) Pressure above 0.76 torr

(c) Pressure above 4.58 torr

(d) Pressure equal to 0.76 torr

12. At what relative humidity will Na_2SO_4 be deliquescent (absorb moisture) when exposed to the air at 0°C?

(a) Below 16.59% (b) Above 16.59%

(c) Above 39.5% (d) Below 39.5%

Answers Key

Subjective Type

1. 60 atm

Single Correct Answer Type

4. (b) **5.** (b) **6.** (d) **7.** (d) **8.** (a)

Multiple Correct Answers Type

9. (a, c)

Comprehension Type

10. (c) **11.** (a) **12.** (b)

CHAPTER 7

Ionic Equilibrium

DPP 7.1

Types of Acids and Bases and Ostwald's Dilution Law

Subjective Type

1. What are $[H^+]$, $[A^-]$ and $[B^-]$ in a solution that contains 0.03 M HA and 0.1 M HB. K_a for HA and HB are 3.0×10^{-4} and 1.0×10^{-10} respectively.
2. Calculate $[H^+]$, $[HCOO^-]$ and $[OCN^-]$ in a solution that contains 0.1 M HCOOH ($K_a = 2.4 \times 10^{-4}$) and 0.1 M HOCN ($K_a = 4 \times 10^{-4}$).
3. Calculate the H^+ ion concentration of a 0.01 N weak monobasic acid. The value of dissociation constant is 4.0×10^{-10}.
4. Identify acid and base in the following reaction according to Bronsted – Lowry concept.
   (a) $[Cu(H_2O)_3(OH)]^+ (aq.) + [Al(H_2O)_6]^{3+} (aq.) \rightarrow [Cu(H_2O)_4]^{2+} (aq.) + [Al(H_2O)_5OH]^{2+} (aq.)$
   (b) $[Fe(H_2O)_5(OH)]^{2+} (aq.) + [Al(H_2O)_6]^{3+} (aq.) \rightarrow [Fe(H_2O)_6]^{3+} (aq.) + [Al(H_2O)_5(OH)]^{2+} (aq.)$
   (c) $O^{2-} (aq.) + H_2O (aq.) \rightarrow 2OH^- (aq.)$
   (d) $CH_3OH (aq.) + H^- (aq.) \rightarrow CH_3O^- (aq.) + H_2 (g)$
5. If the acid-base reaction $HA(aq) + B^-(aq) \rightleftharpoons HB(aq) + A^-(aq)$ has a $K_{eq.} = 10^{-4}$, which of the following statements are true?
   (i) HB is a stronger acid than HA
   (ii) HA is a stronger acid than HB
   (iii) HA and HB have the same acidity
   (iv) B^- is stronger base than A^-
   (v) A^- is stronger base than B^-
   (vi) B^- and HB are conjugate acid-base pair
   (vii) The acid and base strengths cannot be compared
6. Liquid ammonia ionises to a slight extent. At –50°C, its ionisation constant, $K_{NH_3} = [NH_4^+][NH_2^-] = 10^{-30}$. How many amide ions are present per cm³ of pure liquid ammonia? Assume $N = 6.0 \times 10^{23}$.

Single Correct Answer Type

7. The increasing order of base strength is
   (a) $I^- > Cl^- > NO_2^- > CN^-$
   (b) $I^- < Cl^- < NO_2^- < CN^-$
   (c) $I^- < NO_2^- < Cl^- < CN^-$
   (d) $I^- < CN^- < Cl^- < NO_2^-$
8. The following equilibrium is established when hydrogen chloride is dissolved in acetic acid.
   $HCl + CH_3COOH \rightleftharpoons Cl^- + CH_3COOH_2^+$
   The set that characteristics the conjugate acid-base pair is
   (a) (HCl, CH_3COOH) and $(CH_3COOH_2^+, Cl^-)$
   (b) $(HCl, CH_3COOH_2^+)$ and (CH_3COOH, Cl^-)
   (c) $(CH_3COOH_2^+, HCl)$ and (Cl^-, CH_3COOH)
   (d) (HCl, Cl^-) and $(CH_3COOH_2^+, CH_3COOH)$

9. The decreasing base strength of OH^-, NH_2^-, $HC\equiv C^-$ and $CH_3CH_2^-$ is

(a) $CH_3CH_2^- > NH_2^- > HC\equiv C^- > OH^-$

(b) $HC\equiv C^- > CH_3CH_2^- > NH_2^- > OH^-$

(c) $OH^- > NH_2^- > HC\equiv C^- > CH_3CH_2^-$

(d) $NH_2^- > HC\equiv C^- > OH^- > CH_3CH_2^-$

10. % ionization of a weak acid is 1% at 1M, hence % ionization is ..... at 4M.

(a) 4% (b) 5% (c) 0.5% (d) 0.2%

11. BOH is a weak base. Molar concentration of BOH that provides a $[OH^-]$ of 1.5×10^{-3} M $[K_b\,[BOH] = 1.5\times10^{-5}$ M$]$ is

(a) 0.15 M (b) 0.1515 M

(c) 0.0015 M (d) 1.5×10^{-5} M

12. One litre of solution contains 10^{-5} moles of H^+ ions at 25°C. Percentage ionisation of water in solution is:

(a) 1.8×10^{-7} % (b) 1.8×10^{-9} %

(c) 3.6×10^{-9} % (d) 1.8×10^{-11} %.

Multiple Correct Answers Type

13. Which of the following statements are correct?

(a) The leveling effect is not observed in non-aqueous medium.

(b) The strength of an acid having general formula $(HO)_mZO_n$ increases with increase in the value of n.

(c) In a given reaction, the position of equilibrium favours the formation of a weak Bronsted acid and a weak Bronsted base.

(d) The reaction $HCN + OH^- \rightleftharpoons CN^- + H_2O$ is displaced to the right indicating that the acid strength of HCN is greater than water and the base strength CN^- is greater than that of OH^-.

14. Which of the following statements are correct?

(a) Acetic acid is a stronger acid in liquid NH_3

(b) The strongest acid in liquid NH_3 is NH_4^+ ions.

(c) The strongest base in liquid NH_3 is NH_2^- ions

(d) For the reaction $N_2O_4 \rightleftharpoons 2NO_2$ (ΔH = 58.04 kJ mol^{-1}), the density of equilibrium mixture decreases with increase of temperature.

15. If K_{a1} and K_{a2} of H_2SO_4 are 10^{-2} and 10^{-6} respectively, then

(a) $K_{a1} > K_{a2}$ because it is easy to abstract H^+ from H_2SO_4 and less easy to abstract H^+ from HSO_4^-.

(b) K_{a1} and K_{a2} may be measured in acetic acid.

(c) K_{a1} and K_{a2} are measured in H_2O.

(d) The H^+ ion conc. of 0.01 M H_2SO_4 will be less than 0.02 M.

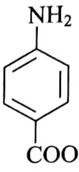
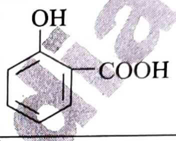
16. K_a values for HA, HB and HD are 10^{-5}, 10^{-7} and 10^{-9} respectively. Which of the following will be correct for decimolar aqueous solutions of NaA, NaB and NaD at 25°C?

(a) $(pH)_{NaA} < (pH)_{NaB}$ (b) $(pH)_{NaD} < (pH)_{NaB}$

(c) $(pH)_{NaA} < (pH)_{NaD}$ (d) $(pH)_{NaB} = 7$

Matching Column Type

17. Match the following.

Column I		Column II	
A.		1.	Lewis acid
B.		2.	Lewis base
C.	$H_2PO_4^-$	3.	Lowry-Bronsted acid
D.	HPO_4^{2-}	4.	Lowry-Bronsted base
E.	HPO_3^{2-}	5.	Zwitter ion
F.	$H_2PO_2^-$	6.	Amphiprotic

Integer Type

18. A mixture of weak acid is 0.1 M in HCOOH ($K_a = 1.8\times10^{-4}$) and 0.1 M in HOCN ($K_a = 3.1\times10^{-4}$). Hence, (H_3O^+) is $x\times10^{-3}$. Thus x is..........

19. How many of the following are amphiprotic?

(i) $H_2PO_2^-$ (ii) $H_2PO_3^-$

(iii) $H_2PO_4^-$ (iv) HPO_3^{2-}

(v) HPO_4^{2-} (vi) NH_4^+

(vii) $CH_3COOH_2^+$

Comprehension Type

Weak acids and bases are not completely ionized when dissolved in polar medium like water.

$$\begin{array}{llcl} & HA & \rightleftharpoons & H^+ + A^- \\ t_0 & c & & 0 \quad\; 0 \\ t_{eq} & c - c\alpha & & \alpha r \quad \alpha r \end{array}$$

$$K_a = \frac{c\alpha^2}{1-\alpha} \approx c\alpha^2$$

$$a = \sqrt{\frac{K_a}{c}}$$

$$\frac{\alpha_1}{\alpha_2} = \sqrt{\frac{K_{a_1}}{K_{a_2}}}$$ (for two acids at same concentration)

$$\frac{\alpha_1}{\alpha_2} = \sqrt{\frac{c_2}{c_1}}$$ (for same acids at different concentration)

Answer the following questions:

20. α_1 and α_2 are in the ratio 1: 2 at same concentration. $K_{a_1} = 2 \times 10^{-4}$, what will be K_{a_2}?

(a) 8×10^{-4} (b) 2×10^{-4}

(c) 4×10^{-4} (d) 1×10^{-4}

21. 0.01 MCH_3COOH is 4.24% ionized. What will be the percentage ionization of 0.1 M CH_3COOH?

(a) 1.33% (b) 4.24% (c) 5.24% (d) 0.33%

22. Relative strength of two weak monoprotic acids may be given as:

(a) $\frac{[H^+]_1}{[H^+]_2}$ (b) $\frac{\alpha_1}{\alpha_2}$

(c) $\sqrt{\frac{K_{a_1}}{K_{a_2}}}$ (d) All of these

Answers Key

Subjective Type

1. 3.33×10^{-9} M **2.** 5×10^{-3} M

3. 2×10^{-6} mol L^{-1} **5.** (i), (v), (vi)

6. 6×10^5 ions

Single Correct Answer Type

7. (b) **8.** (d) **9.** (a) **10.** (c) **11.** (a)

12. (b)

Multiple Correct Answers Type

13. (d) **14.** (a, b, c, d) **15.** (a, b)

16. (a, c)

Matching Column Type

17. (A→2, 3, 4, 5, 6), (B→1, 3), (C→3, 4, 6), (D→3, 4, 6), (E→4), (F→4)

Integer Type

18. (7) **19.** (3)

Comprehension Type

20. (a) **21.** (a) **22.** (d)

DPP 7.2

pH, pK_w, pK_b and pH of Mixture of Acids and Bases

Subjective Type

1. The average concentration of SO_2 in the atmosphere over a city on a certain day is 10 ppm, when the average temperature is 298 K. Given that the solubility of SO_2 in water at 298 K is 1.3653 moles litre^{-1} and pK_a of H_2SO_3 is 1.92. Estimate the pH of rain on that day.
2. Percentage ionization of water at certain temperature is $3.6 \times 10^{-7}\%$. Calculate K_w and pH of water.
3. Calculate the pH of the resulting solution formed by mixing the following solutions:
   (a) 20 mL of 0.2 M $Ca(OH)_2$ + 25 mL of 0.1 M HCl
   (b) 10 mL of 0.01 M H_2SO_4 + 10 mL of 0.01 M $Ca(OH)_2$
   (c) 10 mL of 0.1 M H_2SO_4 + 10 mL of 0.1 M KOH.
4. A 1 litre solution of pH = 6 (solution of a strong acid) is added to the 7/3 litre of water. What is the pH of resulting solution (log 2 = 0.3)? (Neglect the common ion effect on H_2O).
5. Calculate: (a) K_a for a monobasic acid whose 0.10 M solution has pH of 4.52 (log 3 = 0.48).
   (b) K_b for a monoacidic base whose 0.10 M solution has a pH of 10.48.
6. Calculate the change in pH when 4 g of solid NaOH and 10 mmol of H_2SO_4 are added to a solution of volume 5 litre, which was prepared by mixing 20 mmol of HCl. 40 mmol of H_2SO_4 and 2 g of NaOH and sufficient water, Ignore the volume change. (log 2 = 0.3, log 3 = 0.48)

Single Correct Answer Type

7. pOH of H_2O is 7.0 at 298 K. If water is heated at 350 K, which of the following statement should be true?
   (a) pOH will decrease
   (b) pOH will increase
   (c) pOH will remain 7.0
   (d) concentration of H^+ ions will increase but that of OH^- will decrease.
8. A 50 mL solution of strong acid of pH = 1 is mixed with a 50 ml solution of strong acid of pH = 2. The pH of the mixture will be nearly (log 5.5 = 0.74)
   (a) 0.74 (b) 1.26 (c) 1.76 (d) 1.5
9. Which of the following solution will have pH close to 1.0?
   (a) 100 mL of M/10 HCl + 100 mL of M/10 NaOH
   (b) 55 mL of M/10 HCl + 45 mL of M/10 NaOH
   (c) 10 mL of M/10 HCl + 90 mL of M/10 NaOH
   (d) 75 mL of M/5 HCl + 25 mL of M/5 NaOH
10. 0.1 mol HCl is dissolved in distilled water of volume V, then at $\lim_{V\to\infty} (pH)_{solution}$ is equal to
    (a) zero (b) 1 (c) 7 (d) 14
11. Which of the following expressions is not true?
    (a) $[H^+] = [OH^-] = \sqrt{K_w}$ for a neutral solution
    (b) $[H^+] > \sqrt{K_w}$ and $[OH^-] < \sqrt{K_w}$ for an acidic solution
    (c) $[H^+] < \sqrt{K_w}$ and $[OH^-] > \sqrt{K_w}$ for an alkaline solution
    (d) $[H^+] = [OH^-] = 10^{-7}$ M for a neutral solution at all temperatures
12. Milliequivalent of $Ba(OH)_2$ present in 100 mL solution to have pH = 13, is
    (a) 10^{-2} (b) 10 (c) 0.1 (d) 0.01
13. In which case change in pH is maximum?
    (a) 1 mL of pH = 2 is diluted to 100 mL
    (b) 0.01 mol of NaOH is added into 100 mL of 0.01 M NaOH solution
    (c) 100 mL of H_2O is added into 900 mL of 10^{-6} M HCl
    (d) 100 mL of pH = 2 solution is mixed with 100 mL of pH = 12

Multiple Correct Answers Type

14. Equal volumes of following solutions are mixed, in which case the pH of resulting solution will be average value of pH of two solutions.
    (a) Aqueous HCl of pH = 2, aqueous NaOH of pH = 12
    (b) Aqueous HCl of pH = 2, aqueous HCl of pH = 4
    (c) Aqueous NaOH of pH = 12, aqueous NaOH of pH = 10
    (d) Aqueous CH_3COOH of pH = 5, aqueous NH_3 of pH = 9. $[K_a(CH_3COOH) = K_b(NH_3)]$
15. 100 mL of 0.5 M hydrazoic acid (HN_3, $K_a = 3.6 \times 10^{-4}$) and 400 mL of 0.1 M cyanic acid (HOCN, $K_a = 8 \times 10^{-4}$) are mixed. Which of the following is(are) true for the final solution?
    (a) $[H^+] = 10^{-2}$ M (b) $[N_3^-] = 3.6 \times 10^{-3}$
    (c) $[OCN^-] = 5.47 \times 10^{-3}$ (d) None of these

16. 0.1 M CH_3COOH is diluted at 25°C ($K_a = 108 \times 10^{-5}$), then which of the following will be found correct?
   (a) $[H^+]$ will increase
   (b) pH will increase
   (c) number of H^+ will increase
   (d) all the above are correct

17. Which of the following statements is/are not correct?
   (a) Pure water at 40°C has $[H^+] = 10^{-7}$ mol dm^{-3}.
   (b) An aqueous solution having pH = 6.9 at 40°C is acidic in nature.
   (c) pK_w^o of water at 40°C is greater than 14.
   (d) For pure water pH = (1/2) pK_w^o

18. Which of the following solutions when added to 1 L of a 0.01 M CH_3COOH solution will cause no change in the degree of dissociation of CH_3COOH and pH of the solution? $K_a = 1.6 \times 10^{-5}$ for CH_3COOH?
   (a) 0.6 mM HCOOH ($K_a = 8 \times 10^{-4}$)
   (b) 0.1 M CH_3COONa
   (c) 0.41 mM HCl
   (d) 0.01 M CH_3COOH

Matching Column Type

19. (Use log 1.8 = 0.26, K_a of formic acid = 1.8×10^{-4}, K_a of acetic acid = 1.8×10^{-5}, K_b of ammonia = 1.8×10^{-5}, K_{a1} of $H_2S = 10^{-7}$ and K_{a2} of $H_2S = 10^{-14}$, for the following matchings).
Match the entries of column II for which the equality or inequality given in the column I are satisfied.

	Column I		Column II
a.	10^{-5} M HCl solution > 0.1 M H_2S solution	p.	α_{water} (degree of dissociation of water)
b.	CH_3COOH solution at pH equal to 4.74 = NH_4OH solution at pH equal to 9.26	q.	$[OH^-]$
c.	0.1 M CH_3COOH solution = 1.0 M HCOOH solution	r.	α (degree of dissociation of weak electrolytes)
d.	0.1 M of a weak acid HA_1 ($K_a = 10^{-5}$) solution < 0.01 M of a weak acid HA_2 ($K_a = 10^{-6}$) solution	s.	pH

Comprehension Type

The concentration of hydrogen ion is a measure of acidity or alkalinity of a solution.

For mono basic acids:

$$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$$

$$\alpha = \sqrt{\frac{K_a}{C}}$$

where, K_a = Dissociation constant of acid
C = molarity of acid

$$[H^+] = C\alpha,\ [H^+] = \frac{K_a}{\alpha},\ [H^+] = \sqrt{CK_a}$$

pH of a weak acid can be calculated using $[H^+]$ by any of above methods.

$[H^+]_{Total} = \sqrt{C_1K_{a_1} + C_2K_{a_2}}$ (when two weak acids are mixed)

$[H^+]$ of polyprotic acid (Weak, H_3A) (has dissociation constants $K_{a_1} >> K_{a_2} >> K_{a_3}$); will be contributed by first dissociation at the most.

Answer the following questions:

20. What will be the value of $[H^+]$ of 10^{-6} M CH_3COOH? ($K_a = 1.8 \times 10^{-5}$)
   (a) 4.24×10^{-6} M (b) 10^{-6} M
   (c) 9.5×10^{-7} M (d) 10^{-8} M

21. What will be sulphide ion concentration of a dilute solution that has been saturated with 0.1 M H_2S if the pH of the solution is 3?
   $K_{a_1} = 1 \times 10^{-7}$; $K_{a_2} = 1.3 \times 10^{-13}$
   (a) 1.25×10^{-11} (b) 1.3×10^{-13}
   (c) 1.45×10^{-9} (d) 1.30×10^{-15}

22. The pH of 0.01 M HCOOH ($K_a = 1.4 \times 10^{-4}$) will be:
   (a) 2.926 (b) 3.296 (c) 4.962 (d) 5.926

Answers Key

Subjective Type

1. 6.37 2. 4×10^{14}, 6.7
3. (a) 12.82 (b) 7 (c) 1.3
4. 6.4 5. (a) 9×10^{-9} (b) 9×10^{-7}
6. 9.78

Single Correct Answer Type

7. (a) 8. (b) 9. (d) 10. (c) 11. (d)
12. (b)

Multiple Correct Answers Type

14. (a, d) 15. (a, b) 16. (b, c) 17. (a, c)
18. (a, c, d)

Matching Column Type

19. (a→p, q, r, s), (b→p, r), (c→r), (d→p, q, s)

Comprehension Type

20. (a) 21. (d) 22. (a)

DPP 7.3

Salt Hydrolysis

Subjective Type

1. A 0.25 M solution of pyridinium chloride $C_5H_5NH^+Cl^-$ was found to have a pH of 2.75. What is K_b for pyridine, C_5H_5N? (log 2 = 0.3)
2. Calculate the percentage hydrolysis and the pH of 0.02 M CH_3COONH_4, $K_b(NH_3) = 1.6 \times 10^{-5}$, K_a $(CH_3COOH) = 1.6 \times 10^{-5}$.
3. Calculate the degree of hydrolysis of 0.005 M K_2CrO_4. $K_2 = 5.0 \times 10^{-7}$ for H_2CrO_4. (It is essentially strong for first ionization).
4. What is the pH of 0.1 M $NaHCO_3$? $K_1 = 4.5 \times 10^{-7}$, $K_2 = 4.5 \times 10^{-11}$ for carbonic acids. (Given: log 2 = 0.3, log 3 = 0.48)
5. A certain weak acid has $K_a = 1.0 \times 10^{-4}$. Calculate the equilibrium constant for its reaction with a strong base.

Single Correct Answer Type

6. A pair of salts are given in a solution each in 0.1 M concentration. Which solution has a higher pH?
   (a) NaCN and NaOBr (b) NaF and NaOCl
   (c) NaF and NaOBr (d) NaCN and NaOCl
7. Which of the following salts undergoes anionic hydrolysis?
   (a) $CuSO_4$ (b) NH_4Cl (c) $AlCl_3$ (d) K_2CO_3
8. The sodium salt of a certain weak monobasic organic acid is hydrolysed to an extent of 3% in its 0.1 M solution at 25°C. Given that the ionic product of water is 10^{-14} at this temperature, what is the dissociation constant of the acid?
   (a) $\approx 1 \times 10^{-10}$ (b) $\approx 1 \times 10^{-9}$
   (c) 3.33×101^{-9} (d) 3.33×10^{-10}
9. pH of 0.1 M Na_2HPO_4 and 0.2 M NaH_2PO_4 are respectively: pK_a for H_3PO_4 are 2.2, 7.2 and 12.0.
   (a) 4.7, 9.6 (b) 9.6, 4.7
   (c) 4.7, 5.6 (d) 5.6, 4.7
10. The pH of 0.1 M solution of the following salts increases in the order:
    (a) $NaCl < NH_4Cl < NaCN < HCl$
    (b) $HCl < NH_4Cl < NaCl < NaCN$
    (c) $NaCN < NH_4Cl < NaCl < HCl$
    (d) $HCl < NaCl < NaCN < NH_4Cl$
11. The pH of which salt is independent of its concentration:
    (1) $(CH_3COO)\ C_6H_5NH$ (2) NaH_2PO_4
    (3) Na_2HPO_4 (4) NH_4CN
    (a) 1, 2, 3, 4 (b) 1, 4
    (c) 2, 3 (d) 1, 2, 3
12. A weak acid HX has $pK_a = 5$. The per cent degree of hydrolysis of 0.1 M solution of salt NaX is
    (a) 0.001% (b) 0.01%
    (c) 0.1% (d) 0.15%
13. The standard hydrolysis constant of anilinium acetate $K_a(CH_3COOH) = 1.8 \times 10^{-5}$ M, K_b (aniline) $= 4.6 \times 10^{-10}$ M) at 25°C is
    (a) 1.0 (b) 1.21
    (c) 1.35 (d) 2.6×10^{-2}
14. If the equilibrium constant of the reaction of weak acid HA with strong base is 10^9, then pH of 0.1 M NaA is:
    (a) 5 (b) 9 (c) 7 (d) 8
15. Hydrolysis constants of two salts K_a and K_b of weak acids HA and HB are 10^{-8} and 10^{-6}. If the dissociation constant of third acid HC is 10^{-2}. The order of acidic strengths of three acids will be:
    (a) HA > HB > HC (b) HB > HA > HC
    (c) HC > HA > HB (d) HA = HB = HC

Multiple Correct Answers Type

16. Which of the statements are correct?
    (a) Hydrolysis constant of acetate ion is larger than that of cyanide ion
    (b) The degree of dissociation of water increases with increase in temperature
    (c) $pK_w^o = \text{pH} + \text{pOH}$ holes good in any aqueous solution at all temperatures
    (d) The solution of NH_4CN is acidic in nature.
17. Which of the following salts will not undergo hydrolysis?
    (a) NaCl (b) KCl (c) NH_4Cl (d) CH_3COONa
18. Which of the following represents hydrolysis?
    (a) $NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$
    (b) $NH_4^+ + 2H_2O \rightleftharpoons NH_4OH + H_3O^+$
    (c) $HCO_3^- + H_2O \rightleftharpoons H_2CO_3 + OH^-$
    (d) $HCO_3^- + H_2O \rightleftharpoons CO_3^{2-} + H_2O^+$

Matching Column Type

19. Match the following:

	Column I		Column II
a.	$NaHCO_3$ solution	p.	Cationic hydrolysis
b.	$CuSO_4$ solution	q.	Anionic hydrolysis
c.	Potash alum solution	r.	Acidic
d.	NaCN solution	s.	Alkaline

Integer Type

20. Aniline behaves as a weak base. When 0.1 M, 50 mL solution of aniline was mixed with 0.1 M, 25 mL solution of HCl, the pH of resulting solution was 8. Then the pH of 0.01 M solution of anilinium chloride will be ($K_w = 10^{-14}$).

21. The acid ionization (hydrolysis) constant of Zn^{2+} is 1.0×10^{-9}. Hence, pH of 0.001 M solution of $ZnCl_2$ is...... .

Comprehension Type

Consider a solution of CH_3COONH_4 which is a salt of weak acid and weak base.

The equilibrium involved in the solutions are:

$$CH_3COO^- + H_2O \rightleftharpoons CH_3COOH + OH^- \quad (1)$$

$$NH_4^+ + H_2O \rightleftharpoons NH_4OH + H^+ \quad (2)$$

$$H^+ + OH^- \rightleftharpoons H_2O \quad (3)$$

If we add these three reactions, then the net reaction is

$$CH_3COO^- + NH_4^+ + H_2O \rightleftharpoons CH_3COOH + NH_4OH \quad (4)$$

Both CH_3COO^- + NH_4^+ get hydrolysed independently and their hydrolysis depends on

(i) their initial concentration

(ii) the value of K_h which is $\frac{K_w}{K_a}$ for CH_3COO^- and $\frac{K_w}{K_a}$ for NH_4^+.

Since both of the ions were produced from the same salt, their initial concentrations are same. Therefore unless and until the value of $\frac{K_w}{K_a}$ and $\frac{K_w}{K_b}$ or K_a and K_b is same, the degree of hydrolysis of ion can't be same.

To explain why we assume that degree of hydrolysis of cation and anion is same, we need to now look at the third reaction i.e., combination of H^+ and OH^- ions. It is obvious that this reaction happens only because one reaction produced H^+ ion and the other produced OH^- ions. We can also note that this reaction causes both the hydrolysis reaction to occur more since their product ions are being consumed. Keep this thing in mind that the equilibrium which has smaller value of equilibrium constant is affected more by the common ion effect. For the same reason if for any reason a reaction is made to occur to a greater extent by the consumption of any one of the product ion, the reaction with the smaller value of equilibrium constant tends to get affected more:

Therefore we conclude that firstly the hydrolysis of both the ions occurs more in the presence of each other (due to consumption of the product ions) than in each other's absence. Secondly the hydrolysis of the ion which occurs to a lesser extent (due to smaller value of K_h) is affected more than the one whose K_h is greater. Hence we can see that the degree of hydrolysis of both the ions would be close to each other when they are getting hydrolysed in the presence of each other.

22. In the hydrolysis of salt of weak acid and weak base:
(a) degree of hydrolysis of cation and anion is different
(b) degree of hydrolysis of cation and anion is same
(c) degree of hydrolysis of cation and anion is different and they can never be assumed same.
(d) degree of hydrolysis of cation and anion is different but they are very close to each other when they are getting hydrolysed in the presence of each other.

23. For 0.1 M CH_3COONH_4 salt solution given, $K_a(CH_3COOH) = K_b(NH_4OH) = 2 \times 10^{-5}$.
In this case: degree of hydrolysis of cation and anion are
(a) exactly same
(b) slightly different
(c) can't say
(d) different but can be take approximately same

24. In a solution of $NaHCO_3$, the amphiprotic anion can undergo ionization to form H^+ ion and hydrolysis to form OH^- ion.

$$HCO_3^- + H_2O \xrightleftharpoons{\text{ionization}} CO_3^{2-} + H_2O$$

$$HCO_3^- + H_2O \xrightleftharpoons{\text{hydrolysis}} H_2CO_3 + OH^-$$

To calculate pH, suitable approximation is:
(a) $[CO_3^{2-}] = [H_2CO_3]$
(b) degree of ionization = degree of hydrolysis
(c) both (A) and (B)
(d) neither 'A' nor 'B'

Answers Key

Subjective Type

1. 8×10^{-10}
2. 0.625%, 7
3. 2×10^{-3}
4. 8.34
5. 10^{10}

Single Correct Answer Type

6. (a) **7.** (d) **8.** (a) **9.** (b) **10.** (b)
11. (a) **12.** (b) **13.** (b) **14.** (b) **15.** (c)

Multiple Correct Answers Type

16. (b, c) **17.** (a, b) **18.** (b, c)

Matching Column Type

19. (a→q, s), (b→p, r), (c→p, r, q), (d→(q, s)

Integer Type

20. (5) **21.** (6)

Comprehension Type

22. (d) **23.** (a) **24.** (c)

DPP 7.4

Common Ion Effect, K_{sp} and Applications

Subjective Type

1. A solution is prepared by mixing of acetic acid ($K_a = 2 \times 10^{-5}$) and HCl. In the mixture acetic acid is 0.2 M and HCl is 0.1 M. Calculate
   (a) pH of 0.2 M acetic acid and its degree of dissociation.
   (b) pH of final solution
   (c) CH_3COO^- ion concentration in final solution.
   (d) % decrease of α of acetic acid due to common ion effect.
2. Calculate the solubility of silver phosphate (Ag_3PO_4) in mg/mL (a) in pure water and (b) in a solution that is 0.02 M in $AgNO_3$. [$K_{sp}(Ag_3PO_4) = 2.7 \times 10^{-23}$]
3. A mixture of solid $SrSO_4$ and solid $BaSO_4$ is shaken up with water until equilibrium is established. Given that $K_{sp}(SrSO_4) = 7.5 \times 10^{-7}$, $K_{sp}(BaSO_4) = 6 \times 10^{-8}$, calculate the concentrations of Sr^{2+}, Ba^{2+}, SO_4^{2-} in the solution at equilibrium.
4. Equal volumes of 0.002 M solution of sodium iodate and cupric chlorate are mixed together. Will it lead to precipitation of copper iodate? (For cupric iodate $K_{sp} = 7.4 \times 10^{-8}$).
5. Although it is a violent poison if swallowed, mercury (II) cyanide, $Hg(CN)_2$ has been used as a typical (skin) antiseptic. ($K_{sp} = 1.35 \times 10^{-23}$, Hg = 200)
   (a) What is the molar solubility of this salt in pure water?
   (b) How many milligrams of $Hg(CN)_2$ dissolve per litre of pure water?
   (c) How many milliliters of water are required to dissolve 1.134 g of the salt?
6. Calculate the solubility of CaC_2O_4 in a solution with a fixed H_3O^+ concentration of 10^{-4} M. The oxalate containing species ($C_2O_4^{2-}$, $HC_2O_4^-$, $H_2C_2O_4$) exist in solution and the relevant equilibria are,

$$CaC_2O_4(s) \rightleftharpoons Ca^{2+} + C_2O_4^{2-} \qquad K_{sp} = 2.7 \times 10^{-9}$$

$$H_2C_2O_4 + H_2O \rightleftharpoons H_3O^+ + HC_2O_4^- \qquad K_1 = 5 \times 10^{-2}$$

$$HC_2O_4^- + H_2O \rightleftharpoons H_3O^+ + C_2O_4^{2-} \qquad K_2 = 5 \times 10^{-5}$$

7. 100 mL of 0.1(M) $MgCl_2$ solution is mixed with 100 mL of 0.2 NaOH solution.
   Given for $Mg(OH)_2$ $K_{sp} = 12 \times 10^{-12}$. What is the pH of the resulting solution in nearest possible integers?
   $\sqrt{3} = 1.44$; $\log 2.88 = 0.459$

Single Correct Answer Type

8. A well is dug in a bed of rock containing fluorspar (CaF_2). If the well contains 20000 L of water, what is the amount of F^- in it? $K_{sp} = 4 \times 10^{-11}$ ($10^{1/3} = 2.15$)
   (a) 4.3 mol (b) 6.8 mol (c) 8.6 mol (d) 13.6 mol
9. 0.2 millimoles of Zn^{2+} ion is mixed with $(NH_4)_2S$ of molarity 0.02 M. The amount of Zn^{2+} remains unprecipitated in 20 mL of this solution would be (Given : K_{sp} ZnS $= 4 \times 10^{-24}$)
   (a) 5.2×10^{-22} g (b) 2.6×10^{-22} g
   (c) 2×10^{-23} g (d) None of these
10. If the solubility of lithium sodium hexafluoride alumimate, $Li_3Na_3(AlF_6)_2$ is 's' mol, its solubility product is equal to:
    (a) $729\ s^8$ (b) $12\ s^8$
    (c) $3900\ s^8$ (d) $2916\ s^8$
11. The solubility product $Mg(OH)_2$ in water at 25°C is 2.56×10^{-13} $(mol/lit)^3$ while that of $Al(OH)_3$ is 4.32×10^{-34} $(mol/lit)^4$. If s_1 and s_2 are the solubilities of $Mg(OH)_2$ and $Al(OH)_3$ in water in mol/lit at 25°C, what is the ratio, s_1/s_2?
    (a) 2×10^5 (b) 2×10^4
    (c) 3×10^6 (d) 3×10^3
12. The solubility of CaF_2 ($K_{sp} = 3.4 \times 10^{-11}$) in 0.1 M solution of NaF would be
    (a) 3.4×10^{-12} M (b) 3.4×10^{-10} M
    (c) 3.4×10^{-9} M (d) 3.4×10^{-13} M
13. When equal volumes of the following solutions are mixed precipitation of AgCl ($K_{sp}^{\circ} = 1.8 \times 10^{-10}$) will occur only with
    (a) 10^{-4} M Ag^+ and 10^{-4} M Cl^-
    (b) 10^{-5} M Ag^+ and 10^{-5} M Cl^-
    (c) 10^{-6} M Ag^+ and 10^{-6} M Cl^-
    (d) 10^{-10} M Ag^+ and 10^{-10} M Cl^-
14. If s_0, s_1, s_2 and s_3 are the solubilities of AgCl in water, 0.01 M $CaCl_2$, 0.01 M NaCl and 0.05 M $AgNO_3$ solutions respectively, then
    (a) $s_0 > s_1 > s_2 > s_3$ (b) $s_0 > s_2 > s_1 > s_3$
    (c) $s_0 > s_2 > s_3 > s_1$ (d) $s_0 > s_1 = s_2 > s_3$
15. Equal volumes of 0.2 M $AgNO_3$ and 0.1 M NaCl solutions are mixed at 25°C. If $K_{sp}(AgCl) = 1.8 \times 10^{-6}\ M^2$, the concentration of Cl^- ions in the solution will be
    (a) 3.6×10^{-8} M (b) 3.6×10^{-9} M
    (c) 1.34×10^{-5} M (d) 1.34×10^{-6} M
16. The solubility product of $BaCrO_4$ is $2.4 \times 10^{-10}\ M^2$. The

maximum concentration of $Ba(NO_3)_2$ possible without precipitation in a 6×10^{-4} M K_2CrO_4 solution is

(a) 4×10^{-7} M (b) 1.2×10^{-10} M

(c) 6×10^{-4} M (d) 3×10^{-4} M

17. What is the solubility of $Al(OH)_3$, ($K_{sp} = 1 \times 10^{-33}$) in a buffer solution pH = 4?

(a) 10^{-3} M (b) 10^{-6} M (c) 10^{-4} M (d) 10^{-10} M

18. Arrange in increasing order of solubility of AgBr in the given solutions.

(i) 0.1 M NH_3 (ii) 0.1 M $AgNO_3$

(iii) 0.2 M NaBr (iv) pure water

(a) (iii) < (ii) < (iv) < (i) (b) (iii) < (ii) < (i) < (iv)

(c) (iii) < (ii) = (i) < (iv) (d) (ii) < (iii) < (iv) < (i)

Multiple Correct Answers Type

19. In which of the following solutions, the solubility of AgCN will be greater than that in pure water:

Give $K_{sp}(AgCN) = 4 \times 10^{-16}$, $K_a(HCN) = 5 \times 10^{-10}$

(a) 0.01 M Ag NO_3 solution

(b) A buffer solution of pH = 12

(c) 0.2 M NH_3 solution

(d) A buffer solution of pH = 5

20. The solubility of a sparingly soluble salt A_xB_y in water at 25°C = 1.4×10^{-4} M. The solubility product is 1.1×10^{-11}. The possibilities are

(a) $x = 1, y = 2$ (b) $x = 2, y = 1$

(c) $x = 1, y = 3$ (d) $x = 3, y = 1$

21. If you have saturated solution of CaF_2, then:

(a) $[Ca^{2+}] = \sqrt{K_{sp}}$ (b) $[Ca^{2+}] = 2[F^-]$

(c) $2[Ca^{2+}] = [F^-]$ (d) $[Ca^{2+}] = [K_{sp/4}]^{1/3}$

22. Which one is correct for the saturated solution of $Ca_3(PO_4)_2$ salt if its K_{sp} is 2.05×10^{-33}?

(a) Solubility of Ca_3PO_4 is 1.63×10^{-6} M

(b) $[Ca^{2+}]_{eq.} = 4.9 \times 10^{-6}$ M

(c) $[PO_4^{3-}]_{eq.} = 3.26 \times 10^{-6}$ m

(d) $[Ca_3PO_4]_{eq.}$ = Zero

23. If pH of saturated solution of $Ba(OH)_2$ is 12, the value of K_{sp} is not:

(a) 4×10^{-6} M^3 (b) 4×10^{-7} M^3

(c) 5×10^{-6} M^3 (d) 5×10^{-7} M^3

Matching Column Type

24. Match the following:

	Column I		Column II
a.	AgBr	p.	Solubility in water is more than expectation.
b.	AgCN	q.	Solubility in acidic solution is more than that in pure water.
c.	$Fe(OH)_3$	r.	Solubility in strongly basic solution is more than that in pure water.
d.	$Zn(OH)_2$	s.	Solubility decreases in presence of common anion.

Integer Type

25. The solubility of Ag_2CO_3 in water at 25°C is 1×10^{-4} mole/litre. The solubility in 0.01 M Na_2CO_3 solution is $x \times 10^{-5}$ where x is ________.

26. $M[OH]_x$ has $K_{sp} = 4 \times 10^{-12}$ and solubility 10^{-4} M. Hence, x is

Comprehension Type

Strontium fluoride (SrF_2) is a sparingly soluble salt. Let s_1 be its solubility (in mol/lit) in pure water at 25°C, assuming no hydrolysis of F^- ions. Also, let s_2 be its solubility (in mol/lit) in 0.1 M NaF solution at 25°C, assuming no hydrolysis of F^- ions and no complex formation.

However, it is known that $s_1 : s_2 = 10^6 : 256$. Now, answer the following questions.

27. The K_{sp} value of SrF_2 at 25°C is:

(a) 2.048×10^{-9} (b) 1.372×10^{-9}

(c) 1.864×10^{-9} (d) 2.916×10^{-9}

28. The mass of NaF to be added to 100 mL solution of 0.0011 M Sr^{+2} ions to reduce its concentration to 2×10^{-4} M is : [Assume no hydrolysis of F^- ions]

(a) 0.42 g (b) 0.063 g (c) 0.021 g (d) 0.084 g

29. The solubility of SrF_2 (in mol/L) in a buffer solution of pH = 5 at 25°C is: [Given: K_a for HF = $\frac{1}{7} \times 10^{-5}$]

(a) 1.6×10^{-3} (b) 3.2×10^{-3}

(c) 4.8×10^{-3} (d) 6.4×10^{-3}

Answers Key

Subjective Type

1. (a) 0.01 (b) 2×10^{-4} (c) 4×10^{-5} (d) 98%

2. (a) 4.19×10^{-4} gram/lit

(b) 1.414×10^{-15} gram/lit

3. 9×10^{-4} M

4. $K_{IP} < K_{sp}$ → No ppt. formation

5. (a) 1.5×10^{-8} M

(b) 3.78×10^{-3} mg/lit

(c) 3×10^{8} mL

6. 9×10^{-5} M

7. 11.459

Single Correct Answer Type

8. (c) **9.** (a) **10.** (d) **11.** (b) **12.** (c)

13. (a) **14.** (b) **15.** (b) **16.** (a) **17.** (a)
18. (a)

Multiple Correct Answers Type

19. (c, d) **20.** (a, b) **21.** (c, d) **22.** (a, b, c, d)
23. (d)

Matching Column Type

24. (a→s), (b→p, q), (c→q, s), (d→q, r)

Integer Type

25. (1) **26.** (2)

Comprehension Type

27. (a) **28.** (c) **29.** (b)

DPP 7.5

Buffer Solutions

Subjective Type

1. Calculate the mass of $(NH_4)_2SO_4$ in g which must be added to 500 mL of 0.2 M NH_3 to yield a solution of pH = 9.35. K_b for $NH_3 = 1.78 \times 10^{-5}$.
2. A 40 mL solution of weak base BOH is titrated with 0.1 N HCl solution. The pH of solution is found to be 10.04 and 9.14 after the addition of 5.0 mL and 20.0 mL of acid respectively. Find out K_b for weak base.
3. A weak acid HA after treatment with 12 mL of 0.1 M strong base BOH has a pH of 5. At the end point, the volume of same base required is 26.6 mL. Calculate K_a of acid.
4. The solubility of $Pb(OH)_2$ in water is 6.7×10^{-6} M. Calculate the solubility of $Pb(OH)_2$ in a buffer solution of pH = 8.
5. The pH of a buffer is 4.745. When 0.01 mole of NaOH is added to 1 litre of it, the pH changes to 4.832, calculate its buffer capacity.
6. What is the pH of the solution when 0.2 mole of hydrochloric acid is added to one litre of a solution containing 1 M acetic acid and acetate ion? Assume that the total volume is one litre. (K_a for $CH_3COOH = 1.8 \times 10^{-5}$)

Single Correct Answer Type

7. Which of the following can be used as a buffer solution?
   (a) A solution containing NaCl and NaOH
   (b) A solution containing NaCl and NH_4OH
   (c) A solution containing sodium acetate
   (d) A solution containing ammonium acetate
8. On diluting a buffer solution, its pH
   (a) is increased
   (b) is decreased
   (c) remains constant
   (d) changes which cannot be predicted unless dissociation constant of its weak acid (or base) is provided.
9. 0.1 mol of CH_3NH_2 ($K_b^o = 6 \times 10^{-4}$) is added to 0.08 mol of HCl and the solution is diluted to 1 L. The hydrogen-ion concentration in the solution is
   (a) 5×10^{-5} M (b) 8×10^{-2} M
   (c) 1.6×10^{-11} M (d) 6.7×10^{-11} M
10. A buffer of pH = 8.5 is required. If $pK_a^o(NH_4^+) = 9.2$, the amount of $(NH_4)_2SO_4$ to be added in 500 mL of 0.1 M NH_4OH would be
    (a) 0.004 mol (b) 0.005 mol
    (c) 0.006 mol (d) 0.008 mol
11. The pH of resultant solution of 20 mL of 0.1 M H_3PO_4 and 20 mL of 0.1 M Na_3PO_4 is:
    (a) pK_{a_1} (b) pK_{a_2}
    (c) $\frac{pK_{a_1} + pK_{a_2}}{2}$ (d) 2

Multiple Correct Answers Type

12. A buffer solution can be prepared from a mixture of
    (a) sodium acetate and acetic acid in water
    (b) sodium acetate and hydrochloric acid in water
    (c) ammonia and ammonium chloride in water
    (d) ammonia and sodium hydroxide in water
13. Choose the correct statement :
    (a) pH of acidic buffer solution decreases if more salt is added
    (b) pH of basic buffer increases if more salt is added
    (c) pH of acid buffer increases if more salt is added
    (d) pH of basic buffer decreases if more salt is added
14. Which of the following will function as buffer?
    (a) NaCl + NaOH (b) Borax + Boric acid
    (c) $NaH_2PO_4 + NaHPO_4$ (d) $NH_4Cl + NH_4OH$
15. In a buffer solution consisting NaH_2PO_4 and Na_2HPO_4
    (1) NaH_2PO_4 is acid and Na_2HPO_4 is salt
    (2) The pH of solution can be calculated using the relation:
    $$pH = K_2 + \log_{10}\frac{[HPO_4^{2-}]}{H_2PO_4^-]}$$
    (3) The Na_2HPO_4 is acid and NaH_2PO_4 is salt
    (4) The pH cannot be calculated
    (a) 1, 2 and 3 are correct (b) 1 and 2 are correct
    (c) 2 and 4 are correct (d) 1 and 3 are correct
16. In a buffer solution of Na_2PO_4 and Na_2HPO_4:
    (a) NaH_2PO_4 is acid and Na_2HPO_4 is salt
    (b) $pH = pK_2$ of $H_3PO_4 + \log\frac{[HPO_4^{2-}]}{[H_2PO_4^{2-}]}$

(c) Na_2HPO_4 is acid and NaH_2PO_4 is salt

(d) $pH = pK_3$ of $H_3PO_4 + \log \dfrac{[H_2PO_4^-]}{[HPO_4^{2-}]}$

Matching Column Type

17. Column I lists the constituents of a few buffer solution and Column II includes their buffer pH range. Match the correct choice from these two columns.

	Column I		Column II
a.	Acetic acid + Sodium acetate	p.	2.2 – 3.8
b.	Boric acid + Borax	q.	3.7 – 5.6
c.	Borax + NaOH	r.	5.0 – 6.3
d.	Phthalic acid + Potassium acid phthalate	s.	9.2 – 11.0
		t.	6.8 – 9.2
		u.	11.0 – 12.0

Integer Type

18. A certain buffer solution contains equal concentration X^- and HX. Then K_b for X^- is 10^{-10}. The pH of the buffer is:

19. pK_a value of acetic acid is 4.75. If the buffer solution contains 0.125 M acetic acid and 0.25 M sodium acetate, the pH of buffer solution is:

Comprehension Type

Higher the amount of acid or base used to produce a definite change of pH in a buffer solution, higher will be its buffer capacity. Buffer capacity of solution is maximum under the following conditions:

[Salt] = [Acid] (in acid buffer)
[Salt] = [Base] (in base buffer)

pH of a buffer solution lies in the range given below:

$pH = pK_a \neq 1$

In other words, any buffer solution can be used as buffer up to two pH units only, depending upon the value of pK_a or pK_b. A buffer is said to be efficient when $pH = pK_a$ or $pOH = pK_b$.

20. For preparing a buffer solution of pH = 7.0, which buffer system you will choose?

(a) $H_3PO_4, H_2PO_4^-$
(b) $H_2PO_4^-, HPO_4^{2-}$
(c) HPO_4^{2-}, PO_4^{3-}
(d) H_3PO_4, PO_4^{3-}

21. The buffer capacity is equal to:

(a) $\dfrac{\Delta n}{\Delta pH}$
(b) $\dfrac{pH}{\Delta n}$
(c) $\pm 1\, pK_a$
(d) none of these

22. A buffer of acetic acid ($pK_a \approx 4.8$) with sodium acetate will be, when CH_3COOH and CH_3COONa are present in equivalent amounts has pH limits equal to:

(a) 0 to 4.8
(b) 3.8 to 5.8
(c) 4.3 to 5.3
(d) 4.8

23. Buffer capacity is maximum when:

(a) one mole of NH_4Cl is added to two moles of NH_4OH
(b) one mole of NH_4Cl is added to one mole of NH_4OH
(c) one mole of NH_4Cl is added to one mole of NaOH
(d) one mole of NaCl is added to one mole of NaOH

Answers Key

Subjective Type

1. 5.248 g
2. 1.81×10^{-5}
3. 8.219×10^{-6}
4. 1.20×10^{-3} M
5. 0.115
6. 4.5687

Single Correct Answer Type

7. (d) **8.** (c) **9.** (d) **10.** (b) **11.** (b)

Multiple Correct Answers Type

12. (a, c) **13.** (b, c) **14.** (b, d) **15.** (b) **16.** (a, b)

Matching Column Type

17. (a → q), (b → t), (c → s), (d → p)

Integer Type

18. (4) **19.** (5)

Comprehension Type

20. (b) **21.** (a) **22.** (b) **23.** (b)

DPP 7.6

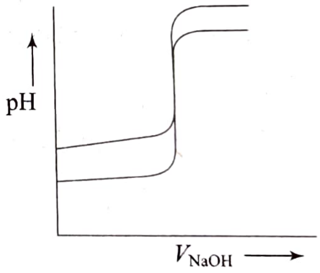
Indicators

Subjective Type

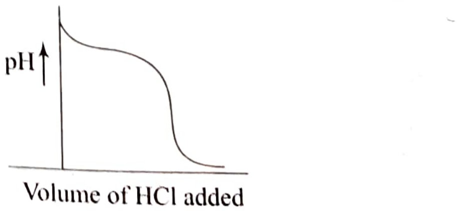
1. Calculate the pH at which an acid indicator with $K_a = 1 \times 10^{-5}$ changes colour when the indicator concentration is 1×10^{-3} M. Also report the pH at which coloured ion is 80% present. (log 2 = 0.3)
2. 15 mL sample of 0.15 M NH_3 (aq) is titrated against 0.1 M HCl (aq). What is the pH at the end point? K_b of NH_3(aq) $= 1.8 \times 10^{-5}$.
3. Calculate the pH during the titration of 40.00 mL of 0.1 M propionic acid (HPr; $K_a = 1 \times 10^{-5}$) after adding the following volumes of 0.1 M NaOH : (log 2 = 0.3, log 3 = 0.48)
   (a) 0.00 mL
   (b) 30.00 mL
   (c) 40.00 mL
   (d) 50.00 mL
4. A 0.252 g sample of unknown organic base is dissolved in water and titrated with a 0.14 M HCl solution. After the addition of 20 mL of acid, a pH of 10.7 is recorded. The equivalence point is reached when a total of 40 mL of HCl is added. The base and acid combine in a 1 : 1 ratio.
   (a) What is the molar mass of the organic base?
   (b) What is the K_b value of the base?
5. An acid indicator, HIn differs in colour from its conjugate base (In^-). The human eye is sensitive to colour differences only when the ratio $[In^-]/[HIn]$ is greater than 10 or smaller than 0.1. What should be the minimum change in the pH of the solution to observe a complete colour change ($K_a^o = 1.0 \times 10^{-5}$)?

Single Correct Answer Type

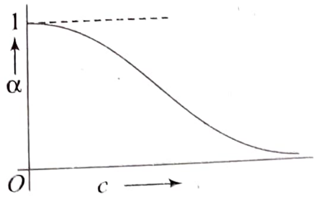
6. At 25°C pH range of phenolphthalein is 8 – 10. At 100°C pH range of phenolphthalein would be
   (a) pH range remain unaffected by the temperature
   (b) pH range is altered to 8 to 9
   (c) pH range is altered to 7 to 11
   (d) pH range is altered to 8 to 11
7. A certain indicator (an organic dye) has $pK_a = 5$. For which of the following titrations may it be suitable.
   (a) acetic acid against NaOH
   (b) aniline hydrochloride against NaOH
   (c) sodium carbonate against HCl
   (d) barium hydroxide against oxalic acid
8. An acid base indicator which is a weak acid has a pK_{In} value = 5.45. At what concentration ratio of sodium acetate to acetic acid would the indicator show a colour half-way between those of its acid and conjugate base forms? [pK_a of acetic acid = 4.75, log 2 = 0.3]
   (a) 4 : 1
   (b) 6 : 1
   (c) 5 : 1
   (d) 3 : 1
9. Which is/are correct statements?
   (i) In any strong acid's solution, the concentration of $[OH^-]$ will be zero.
   (ii) If ΔG^o of a reaction is positive, then the reaction will not proceed at all, in the forward direction for any concentrations of reactants and products.
   (iii) Titration curves are drawn for (about the figure shown).



   (a) 1 M HCl (50 mL) with 1 M NaOH and
   (b) 0.01 M HCl (50 mL) with 0.01 M NaOH on the same graph paper they look like:
   (a) (i) and (ii)
   (b) (iii) only
   (c) (ii) only
   (d) (i) and (iii)
10. Which is/are correct statements?
   (i) When 100 mL of 0.1 M NaCN solution is titrated with 0.1 M HCl solution the variation of pH of solution with volume of HCl added will be (as shown in figure):



   (ii) Variation of degree of dissociation α with concentration for a weak electrolyte at a particular temperature is best represented by (as shown in figure).



(iii) 0.1 M acetic acid solution is titrated against 0.1 M NaOH solution. The difference in pH between 1/4 and 3/4 stages of neutralization of acid will be 2 log 3.

(a) i and iii (b) ii and iii
(c) i, ii and iii (d) ii only

11. 20 mL of a weak monobasic acid (HA) requires 20 mL 0.2 M NaOH for complete titration. If pH of solution upon addition of 10 mL of this alkali to 25 mL of the above solution of HA is 5.8. The pK_a of the weak acid is

(a) 6.1 (b) 5.8
(c) 5.98 (d) 5.58

12. What is the difference in pH for 1/3 and 2/3 stages of neutralization of 0.1 M CH_3COOH with 0.1 M NaOH?

(a) 2 log 3 (b) 2 log (1/4)
(c) 2 log (2/3) (d) 2 log 2

13. The pink colour of phenolphthalein in alkaline medium is due to

(a) the acidic form of phenolphthalein
(b) the anionic form of phenolphthalein
(c) OH^- of the alkali
(d) The non-conjugated structure of phenolphthalein

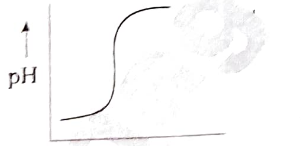
Multiple Correct Answers Type

14. An acid-base indicator has a K_a of 3.0×10^{-5}. The acid form of the indicator is red and the basic form is blue. Then

(a) pH is 4.05 when indicator is 75% red
(b) pH is 5.00 when indicator is 75% blue
(c) pH is 5.00 when indicator is 75% red
(d) pH is 4.05 when indicator is 75% blue

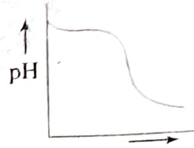
15. Which one is the correct graph (figure) for the corresponding acid base titration?

(a)



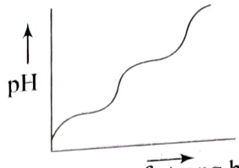
volume of strong base added to a monobasic strong acid

(b)



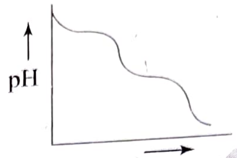
Volume of strong acid added to a monoacidic weak base

(c)



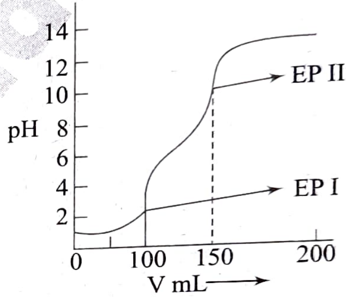
volume of strong base added to a weak dibasic acid

(d)



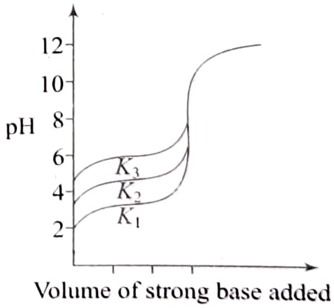
volume of strong acid added to a weak diacidic base

16. A weak acid (or base) is titrated against a strong base (or acid), volume v of strong base (or acid) is plotted against pH of the solution (as shown in figure). The weak electrolyte (i.e. acid or base) could be



(a) Na_2CO_3 (b) $Na_2C_2O_4$
(c) $H_2C_2O_4$ (d) $CH_2(COOH)_2$

17. Titration curves for 0.1 M solutions of three weak acids HA, HA_2 and HA_3 with ionization constants K_1, K_2 and K_3 respectively are plotted as shown in the figure. Which of the following is/are true?



(a) $K_2 = (K_1 + K_3)/2$ (b) $K_1 < K_3$
(c) $K_1 > K_2$ (d) $K_2 > K_3$

18. Titration curves for 0.1 M solutions of three weak acids HX, HY and HZ with ionization constants K_1, K_2 and K_3 respectively as shown in figure below:

(a) $K_2 = \frac{K_1 + K_3}{2}$ (b) $K_1 < K_3$
(c) $K_1 > K_2$ (d) $K_2 > K_3$

Matching Column Type

19. Match the following:

	Column I		Column II
a.	Buffer capacity is maximum for an acid buffer is	p.	$\text{pH} = pK_a + \log \frac{1}{3}$
b.	At the $\frac{1}{4}$th of the equivalence point for the titration of weak acid HA	q.	$\frac{1}{2}(pK_a + \log 3)$
c.	At the $\frac{3}{4}$th of the equivalence point for the titration of weak acid HA	r.	$\text{pH} = pK_a - \log \frac{1}{3}$
d.	The pH of $\frac{1}{3}$ (M) solution of weak acid HA	s.	$\text{pH} = pK_a$

Integer Type

20. K_b of an acid-base indicator H is 10^{-9}. The pH at which its 10^{-3} (M) solution shows the colour change is....

21. In the titration of a solution of a weak acid HX with NaOH, the pH is 5.8 after 10.0 mL of NaOH solution has been added and 6.402 after 20.0 mL of NaOH has been added. What is the ionization constant of HX?

Comprehension Type

A solution of paranitrophenol indicator of concentration 6×10^{-4} (M) was prepared and indicator solution was used in the spectrophotometric measurement. The experimental results are tabulated as below:

Condition	Form of indicator	Absorbance
Strongly Acidic	HIn	0.142
Strongly Alkaline	In^-	0.943
pH = 8	$HIn + In^-$	0.527

Given: log 2 = 0.3; log 3 = 0.48;
log 5 = 0.7; log 7 = 0.85

22. What is the molar concentration of In^- at pH = 8?
(a) 3.11×10^{-4} (M) (b) 2.88×10^{-4} (M)
(c) 6×10^{-4} (M) (d) None of these

23. What is the K_{in} of the indicator?
(a) 3.117×10^{-4} (b) 6.12×10^{-9}
(c) 9.25×10^{-10} (d) 9.25×10^{-9}

24. Which of the following is/are true regarding the choice of indicator?
(a) At the neutral point of the indicator $[In^-][HIn]$
(b) At the equivalence point of acid-base titration entire amount of acid is neutralized by the base
(c) The equivalence point may or may not be equal to the neutral point of indicator
(d) Best indicator to identify the end point of the acid-base titration is such indicator for which pH corresponding to equivalence point lie within the $pK_{in} \pm 1$

Answers Key

Subjective Type

1. 5, 5.6
2. 5.24
3. (a) 3 (b) 5.48 (c) 8.85 (d) 12.04
4. (a) 45 (b) 5×10^{-4}
5. The pH of the solution should change from 4 to 6.

Single Correct Answer Type

6. (b) **7.** (c) **8.** (c) **9.** (b) **10.** (c)
11. (c) **12.** (d) **13.** (b)

Multiple Correct Answers Type

14. (a, b) **15.** (a, b, c, d) **16.** (c, d)
17. (c, d) **18.** (c, d)

Matching Column Type

19. (a→s), (b→p), (c→r), (d→q)

Integer Type

20. (5) **21.** (6.1)

Comprehension Type

22. (b) **23.** (d) **24.** (d)